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GERMAN NEW GUINEA.

GERMANY'S largest protectorate in the Pacific Ocean, Kaiser Wilhelm Land, has not received the attention it deserves, but the recent discussion in regard to it in the Reichstag has given a little more prominence to this land so richly endowed by nature. One reason for this apparent neglect is that it has undergone so many changes within a short time that even those well versed in colonization matters have found it difficult to keep track of it. Lately, however, most of the agricultural interests have centered at Astrolabe Bay. Here, especially at Stephansort, great attention has been given to the cultivation of tobacco. The station Erima, on Erima Harbor, is an insignificant place consisting of a few dwellings, built in Sumatra style, for the manager and other officials, and a few storehouses, with the recent addition of a sawmill for preparation of the wood that is exported for the manufacture of furniture, which has lately become quite a brisk business; but the place owes its existence entirely to the traffic between it and Stephansort, for it is only an open roadstead where the sea is often very high, but, as the name indicates, the landing is protected by two reefs.

The best way to reach Stephansort is by means of the narrow gage railroad, the little passenger cars of which are drawn by oxen. This road and its branches, according to the latest reports, have attained a length of seven and a half miles. The oxen are much cheaper and are more

Erima. Sawfish caught by Chinese fisherman. Road from Bogaujim to the Hospital of Stephansort.

SCENES IN GERMAN NEW GUINEA.

easily managed than engines, and, on the whole, answer very well for a road with so little business, especially as all engines used in the tropics need great care and many repairs. Stephansort is divided into several districts, according to the crops—tobacco, cotton or coffee—raised in them. The cultivation of tobacco pays best, under favorable circumstances, but more hands are required for this crop, because it requires more care than the others. The clearing and draining of the land alone is very expensive. When the ground has been properly prepared and the seed sown, it is necessary to provide it with a covering of short grass or leaves as a protection from the scorching sun, and then, after the plants begin to grow, they must be carefully watched and protected from insects and other enemies. For this and other work the company has imported Chinese coolies, with whose help the tobacco of Sumatra has been brought to such a satisfactory condition; but the workers brought from Java and other islands of the Pacific are quite different, and it is difficult to make the Papuans of Kaiser Wilhelm Land work at all. We cannot here enter into a description of the details of the work required for raising tobacco; it is sufficient to say that in sixty to ninety days (according to the weather) after planting it is ready to be cut and carried to the long sheds seen in the illustration, in which the foot hills of the Finisterre Mountains form the background. The working force of Stephansort and Erima consists of about 300 Chinese, 250 men and 160 women from Java and 600 Melanesians, making a total of 1,310. The Chinese are also active as merchants and fishermen, and it often happens that the latter land dangerous inhabitants of the sea, such as sawfish and hammerfish.

The working force is well cared for, especially in case of illness, for the hospital includes an isolated building, separate buildings for men and women, one for internal and one for external diseases. The people represented in one of our illustrations as looking at a sawfish are "walking patients," and back of them we can see the hospital, which is approached by an avenue of young cocoanut palms, the beautiful foliage of which seems to grow directly out of the ground. These cocoanut palms are the typical trees of the islands of the South Pacific, constituting the characteristic feature of the coast landscapes. Their fruit supplies nourishment for the natives, the leaves are used as a roofing material, the veins of the leaves for all kinds of basket work, the hard bark of the fruit for ropes, and finally, there is the palm wine, which, when fermented, makes an intoxicating drink. So it will be seen that the cocoanut palm, which will grow even in poor ground, is one of the most useful and at the same time one of the most beautiful trees of the tropics.—Ueber Land und Meer.

One of the largest Belgian smelting works has constructed a motor which utilizes in an efficient manner the gases escaping from smelting furnaces.—Revue industrielle.

Tobacco plantation at Stephansort; Nasenberge in the background.

New Mecklenburger with decorative scar. Native of Bonga, near Constantine Harbor.

Workman from Nuss Island, in Bismarck Archipelago (ears cut and spread by way of decoration). Native of Huon Gulf.

Family in the Village of Lalu.

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THE EGG OF THE DUNG BEETLES.

THE question of the egg of the dung beetles, which was for a long time an obscure one, has finally been solved by Mr. J. H. Fabre, of Avignon, who has recently published the results of his investigations in the fifth series of his Souvenirs Entomologiques.

The dung beetles are insects that live on the excrement of large animals. One of the most curious of them

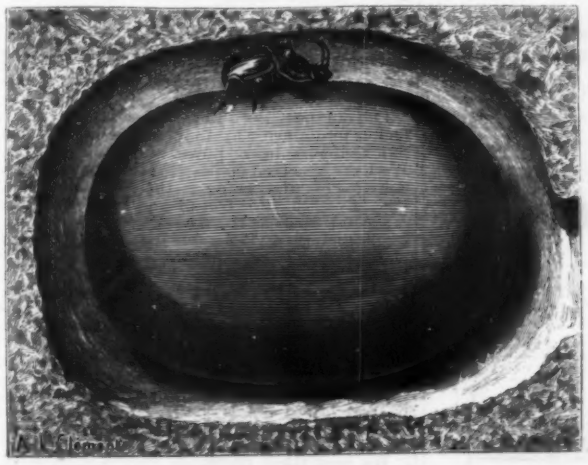


FIG. 1.—DUNG BEETLE ROUNDING A BALL IN ITS NEST.

is certainly the sacred scarabæus, which was adored in Egypt after the manner of a god.

Despite their habits, which at first sight appear repugnant, these insects are interesting in more senses than one. They have, in fact, the singular habit of forming large balls of dung, which they laboriously roll to a distance and inclose in a hole in the ground, which they also enter. It was formerly thought that the insect deposited an egg in this ball, but it is now known that it uses the latter as food. But how is the beetle reproduced? In order to find this out, Fabre made an innumerable series of observations and experiments, in

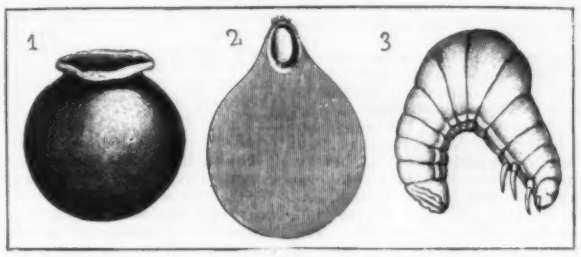


FIG. 2.—SACRED SCARABÆUS.

1. Ball with the cavity designed to receive the egg. 2. Longitudinal section of a ball. 3. Larva of the beetle.

which he reared the insects in cages constructed for the purpose and fed them upon mule, horse and cow dung, which he gathered in the vicinity, and thereby, as may be conceived, acquired for himself a singular reputation. He saw the balls formed before his eyes, but all were afterward devoured. He never came across an egg in the interior of those formed in captivity, any more than he did in those collected in the fields. In the cages the beetles died without leaving any offspring. They were to keep their secret for some time to come, and it was almost an accident that revealed it. We say almost, because here, as everywhere else, an accident is favorable only to those who cause it. Fabre, in fact, had made the acquaintance of a young shepherd whom he had found to be intelligent and whom he had asked to note the habits and movements of the beetle. Now one day the shepherd observed an insect coming out of the ground, and having made an excavation at the place of its exit, found a small pear-shaped object which he at once carried to Fabre. This curious object looked as if it had come from the shop of a turner. It did not yield to the pressure of the fingers and had a very artistic curve. Other specimens were afterward found and proved to be the maternal work of the beetle. In fact, the mother was several times detected in company therewith (Fig. 3).

The nest of the insect is revealed externally by a small heap of dirt, beneath which opens a well from which starts a sinuous horizontal gallery that ends in a large chamber in which one's fist might be placed. It is upon the floor of this chamber that the pear lies, with its long axis horizontal. The greatest dimensions are 1¾ inch in length and 1¼ in width and the smallest 1¾ and 1 inch. The surface is carefully smoothed under a thin layer of red clay. Soft at the outset, it soon hardens through desiccation, so as no longer to yield to the pressure of the fingers.

When we take into account the material of which the pears are formed, we have at once an explanation of Fabre's want of success in his cage experiments. The pears are, in fact, formed wholly of the droppings of sheep. The beetle itself is satisfied with the excrement of the horse and mule, but for its offspring it selects a softer, more nourishing and more plastic paste. If this is not furnished to it, the beetle refuses to nidificate, and this is what happened in Fabre's experiments. It will be seen that success in natural history experiments often depends upon trivial things.

The egg is placed in the narrow part or neck of the pear in a cavity with polished and shining walls. It is 0·4 of an inch long and 0·2 of an inch in thickness, and adheres only by its posterior extremity to the top of the cavity (Fig. 2, No. 2). Why is the egg placed here and not in the center of the pear, where it would seem as if it would be better protected against the vicissitudes of the weather? Doubtless in order to permit the oxygen of the air to come more easily into contact with the egg and the nascent larva. As for the rounded form of the nidus, that is explained by the necessity recognized by the beetle of diminishing evaporation, the effect of which would be to "stale the bread" too much that is fed to the larva. Now the sphere is the form that contains the most material with a minimum surface, that is to say, one best adapted for diminishing evaporation. The incubating part, which elongates this sphere into a pear, is in a manner an addition to the food storehouse.

The manufacture of the pear is effected in several manners. The ball is often formed in place and then rolled to a distance to a point where it is easy to make an excavation. Here the ball is stored up just as it is or else first cut up outside and then made over again in order to be introduced into the burrow. At other times the sheeps' droppings are gathered just as found and introduced into the nest, where they are formed into a ball. It is very difficult to follow the manufacture of the latter, since the insect can work only in darkness. As soon as it perceives a light it scampers away and abandons its nest. Nevertheless, by rearing it in a glass bowl placed in darkness and in making rapid inspections, Fabre was enabled to follow the different phases. The ball is constructed in place, and that, too, without any rolling over the ground in order to give it rotundity. After it is finished, the beetle forms upon the side a circular projection circumscribing a sort of shallow crater. In this state the work resembles certain prehistoric pots. It is in this crater that the egg will be laid, and the edges brought together above will constitute the tapering part of the pear (Fig. 2, No. 1).

The incubation lasts but a short time. Under the influence of the sun's heat, the egg hatches in from five to ten days, and the worm immediately begins to devour the food placed within its reach. The entire supply gradually disappears, but the insect does not touch the crust, which is so useful as a protection against the external heat. Here may be recorded a fact which is worthy of remark and certainly very strange. If a hole be made in the external crust, the head of the larva will at once be seen to appear and then to disappear. Immediately afterward the aperture will be closed by a soft brown paste that hardens very rapidly. A priori, it might be thought that the worm had used a portion of its food to stop up the hole. This would be a waste that the larva is too sensible to indulge in. The substance is nothing more than its own excrement, which it spreads out with the trowel-shaped posterior part of its body (Fig. 2, No. 3). The larva, moreover, always holds in reserve a large amount of this plaster, so that it is capable of closing five or six times in succession any breach that a person may persist in making. The worm, with the same material, unites the pieces of the ball when the latter chances to get broken. This cementing property of the excrement is very valuable to it, since the pears are often attacked by mould, which has a tendency to cause them to crack. Thanks to the plaster injected into the fissures, the larva puts a check upon this devastating work of the fungus in short order.

In four or five weeks the complete development has been accomplished. Before becoming transformed into a pupa, the larva doubles and triples the thickness of the wall of what remains of the pear, and always with the aid of its plaster, of which, as before stated, it keeps a large stock on hand.

It is in August generally that the insect is ready for deliverance, and this is a grave moment for it. If, in fact, the weather remains dry, it is impossible for it to get out of prison. In order that it may deliver itself, it is necessary to wait for rain. Then the insect, using its legs and pushing with its back, casts off the earth, which has become soft, and makes its exit. This is, perhaps, the origin of the Egyptian fable that represents the mother scarabæus as being obliged to throw her ball into the Nile in order to liberate her offspring. At all events, the coincidence is curious.

The other Scarabæidæ behave nearly in the same way as the sacred scarabæus, with a few exceptions. Thus the wide-necked scarabæus stores in its nest two pears

FIG. 4.—FEMALE COPRIS WATCHING OVER FOUR BALLS THAT CONTAIN EGGS.

FIG. 3.—FEMALE SCARABÆUS FINISHING A BALL IN WHICH SHE HAS DEPOSITED AN EGG.

instead of one. In each of these, of course, an egg is laid.

The Gymnopleures (dung beetles of rapid flight and acute sense of smell) do not manufacture their balls and roll them to a distance until the moment of reproduction. They dig their nest at a depth of two or three inches, and from the ball brought thereto form a new one of the size and shape of a sparrow's egg.

The genus Copris presents us with facts that are still more interesting. The beetles belonging to this genus, in fact, never form balls, except at the time of reproduction. When they have discovered a good mass of dung, they excavate beneath it a long gallery terminating in a chamber of the size of the fist. Here the beetle stores up a large quantity of food which it will eat at its leisure.

At the moment of oviposition, in May and June, the insect abandons the excrement of horses and oxen and seeks the soft product of the sheep. It digs a hole under this and buries it entire in situ. What is curious is that both sexes take part in excavating the gallery and chamber, but as soon as the work is finished, the male goes away and leaves the female to herself. The mass stored up assumes various forms—ovoid, like the egg of the turkey, round like a Dutch cheese, or circular and slightly inflated at the upper part; but the surface is always smooth and regularly curved (Fig. 1). Moreover, the Copris can often be detected in the act of walking over the surface of its ball in order to consolidate and equalize it. It may be asked what is the use of all this work, since the mass is destined to be divided up. Perhaps such work and the time that it consumes improves the mass and permits it to ferment. However this may be, the division into lumps is soon proceeded with. By means of a circular incision made with the "knife of the head and the saw of the hind legs," says Fabre, the beetle detaches from the piece a fragment having the proper bulk and at once proceeds to shape it. Clasping it in its short legs, which do not appear to be adapted for such work, the insect rounds off the piece by simple pressure. It then moves up and down and around the as yet somewhat shapeless mass, presses it methodically a little more here and a little more there, retouches it with untiring patience, and at the end of twenty-four hours has produced a perfect sphere of the size of a plum. But the insect still continues to improve and polish its sphere until the least projection has disappeared. It seems as if its careful retouchings would never finish. Toward the end of the second day, however, the globe is deemed perfect. The mother now ascends the ball and forms a shallow crater therein by simple pressure; and in this the egg is deposited. Then, with a delicacy that is surprising with tools so rude, the edges of the crater are brought together in order to form a dome over the egg. After further careful manipulation, an ovoid is produced with the small end pointing upward.

The mother then visits the mass and cuts therefrom material for the manufacture of two or three more ovoids. It is a matter worthy of remark that during all this time the insect does not eat. After oviposition, the mother, instead of departing, as does the female of the scarabæus, remains in her burrow and watches over her offspring. This is a fact that is unique in the order of Coleoptera. The females do not emerge until September, that is to say, at the time that their offspring become adult.

In the burrow the female is constantly going from one egg mass to another and feeling and scraping and retouching it, so that the ovoids are always absolutely clean and no mould is observed upon them or fissures in them, as is the case of the balls of the scarabæus.—Condensed from La Nature.

ANTIQUITY OF SIGNALING.

CHARLES BRIGHT, in The Cornhill Magazine, tells us that the fabulous honor of being the first inventor of the art of signaling is bestowed by certain classical writers upon the ingenious Palamedes, but it is certain that, long before the time of the Trojan war, the Egyptians and Assyrians, if not the Chinese and other nations of remote antiquity—of whom monumental records alone remain to us—had developed regular methods of signaling by fire, smoke, flags, etc. Signals were passed from tower to tower of the great wall of China, and the tower of Babel was a signal tower. Beacons are "as old as the hills" on whose summits they were placed. Those lighted on Mounts Ida, Athos, Cithæron, and intervening heights, conveyed information of the taking of Troy by Agamemnon. Leander was guided across the Hellespont by the signal lamp displayed by Hero in her tower at Sestos. One night the lamp was blown out—he was drowned, and she then threw herself into the waves. Theseus, in the Argonautic expedition, conveyed information by colors of the sails hoisted, but killed his father through a telegraphic error; for, flushed with victory, he forgot his signal, and old Ægeus, seeing the black sail, and feeling sure his son was dead, flung himself into the sea.

The use of mirrors to flash signals by the sun's rays dates back to the time of the Pharoahs. The Persians are said to have considerably developed it for purposes of war.

The Persians, the Gauls, and the Aztecs communicated by relays of sentinels shouting to one another, and Alexander, by means of the stentorophonic tube, conveyed his orders for four leagues. The tactician Arnios communicated at night by means of a tall vessel containing water, which was let out slowly by a tap at the bottom; on the water floated a cork disk carrying a gage with divisions down the side, and on each division a separate sentence was inscribed. Each signaling point had one of these contrivances; and on a light being shown from one station it was acknowledged by the other, and each clepsydra opened at the moment. When the surface of the water receded to the sentence required, the signaling station again showed a light, when the other stopped the outflow and read the words inscribed at the water level upon the corresponding gage.

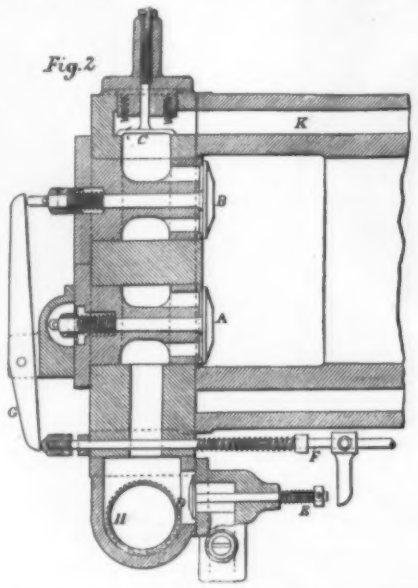
Hannibal erected watch towers in Africa and Spain to signal from; and whenever the Romans extended their conquests in Gaul, Spain or elsewhere, they made use of similar signaling devices. A representation of one of their telegraph towers is engraved on Trajan's Column, and ruins of some of them are still to be seen in various parts of France.

We present this information for the benefit of our signal officers, says The Army and Navy Journal, to show them how ancient and honorable is the fraternity to which they belong.

THE WHITE & MIDDLETON GAS ENGINE.

OUR American friends, says London Engineering, have invaded our home market in many directions, but hitherto they have not attempted to sell gas engines here. Recently, however, a gas engine invented by Mr. Charles White and Mr. A. R. Middleton, of Baltimore, has been on exhibition at 29 Queen Victoria Street, London, and has attracted considerable attention on account of its simplicity and of the considerable claims made for it on the score of economy. As shown by the engraving below, the engine does not differ much in general appearance from the types with which we are familiar, except that one misses many of the levers and cams which usually work the valves. Further, as the engine works on the Otto or four-stroke cycle, it follows European engines in the main features of operation.

Fig. 2



The chief point of difference is in the use of two exhaust passages. The first ends in an open port, which is uncovered by the piston as it nears the end of its stroke. As the piston is almost stationary at this point for an appreciable period, the burned gases have a considerable time in which they can escape, and at least three-quarters of them do so, the remainder being cooled by expansion to a very moderate temperature. What is left is pushed back by the piston, and emitted through the valves, B and C, and the passage, K, the latter joining the main exhaust passage. The valve, C, is a check valve to prevent the first rush of gases getting to the underside of the valve, B, when the engine has a very long exhaust pipe, as often occurs in the high buildings of American cities. The expelling valve, B, is opened by the lever, G, operated by the rod, F, this rod taking the place of the side shaft usually found in such engines. It is worked by a cam driven by one to two gearing from the crankshaft, the length of its traverse depending on a hit-and-miss motion operated by the governor. The expelling valve is always opened on the exhaust stroke, but the stroke of the rod is only long enough to open the gas valve when the speed of the governor does not exceed the normal. At other times the tappet does not strike the stem, E, of the gas valve, D. The gas enters through the regulating screw shown; it then passes the valve, D, and meets the air coming through the pipe, H. On the suction stroke the gaseous mixture is drawn through the valve, A, to be compressed, and then fired by an incandescent tube. This tube is provided with a "timing" valve which is moved by the piston at the end of the return stroke, so that early ignitions are impossible.

The engine shown in the woodcut has a cylinder 6½ inches in diameter by 18 inches stroke, its power being 13·6 indicated horse power and 12 brake horse power. We have received copies of a number of tests of efficiency. The first, made at the New York exhibition of 1890, gives 19 cubic feet of gas per brake horse power A second, made at the American Institute Fair, December 8, 1891, gives 16·3 cubic feet per brake horse power, at 8·2 brake horse power, 18·28 cubic feet at 3·96 horse power, and 16·02 feet at 9·42 brake horse power. A trial made by Mr. Perrey F. Nursey in London, in June, 1897, gives 17·5 cubic feet, 19·25 cubic feet and 40·2 cubic feet per brake horse power respectively at full power half power and light load, gas supplied by the Gas Light and Coke Company being used. An earlier trial, made on March 1, 1897, by Mr. George William Usill, gives 17·57 cubic feet per brake horse power with a load of 12·3 brake horse power, 17·38 cubic feet with 12·5 brake horse power, 19 cubic feet with 7 brake horse power and 41·6 cubic feet light loaded.

We give these results as they were furnished to us. They are exceedingly good, and we do not remember to have ever seen them beaten by an engine of the same size. As far as our memory serves, the best published results attained by a small engine in this country are those which Mr. Dugald Clerk incorporated in his paper on "Recent Developments in Gas Engines," read before the Institution of Civil Engineers on January 28, 1896. The engine in question was constructed by Messrs. Crossley Brothers, and was tested by Mr. Clerk himself with all possible care. It had a 7-inch cylinder with a 15-inch stroke, and "gave practically 12 brake horse power with a gas consumption of only 17 cubic feet of gas per brake horse power per hour, a surprisingly good result for so small an engine." Manchester gas has slightly more heating value than London gas, since it requires theoretically 3·736 cubic feet of Manchester (Openshaw) gas to develop one horse power for an hour, while it requires 3·955 cubic feet of the Gaslight and Coke Company's gas for the same purpose. Therefore, with London gas the consumption would be somewhat increased, although it is difficult to say how much, since gas is a variable substance, and analyses cannot be taken too literally. Anyway, it is high praise for an engine to say that it is as economical as the Crossley-Atkinson scavenger engine.

The earliest form of mechanical stoker of which there is any record was the one patented in 1785, by James Watt. It consisted of two sets of horizontal grate bars, one behind the other, which were worked intermittently by means of levers operated by hand. The coal was fed in at the door and pushed back as it became coked, the gases from the fresh fuel passing over and through the fuel in more advanced combustion at the bridge end of the grate. It was designed primarily to prevent smoke from bituminous coal, and was quite successful.

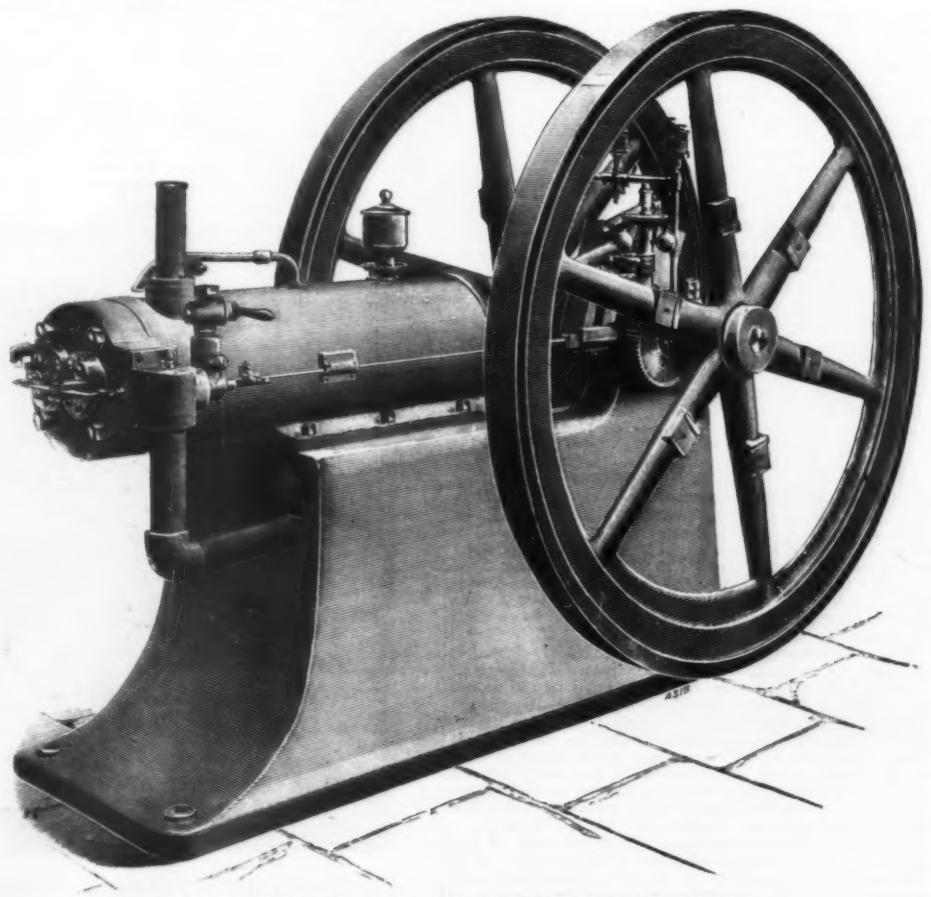


FIG. 1.—THE WHITE & MIDDLETON GAS ENGINE.

TESTS OF BICYCLE WHEELS.

I RECENTLY conducted a series of tests of latest patterns of bicycle wheels with a view of determining their efficiency. Several groups of wheels were furnished by manufacturers of standard bicycles, all 28 inch wood rims, 36 spokes, each 11 inches long and of No. 14 wire. The spokes were set tangent, with the hub suspended from groups of four vertical spokes in pairs in about the usual form. No one of the crossings of the spokes was tied. The object of the tests being to

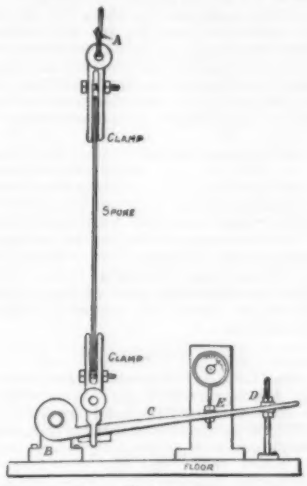


FIG. 1.

obtain definite calculations as to the strength of the wheels, the spoke material was first tested. Not finding just the kind of apparatus required for this work in the markets, the writer designed that shown in the views, in which Fig. 1 is for determining the load which a single spoke can sustain. Steel clamps grip either end of the spoke, one of which is suspended from above by a wire cord, A, and the other is attached to the lever, C. This lever is studded to the stand, B, and the latter is set screwed to the floor. An upright threaded bolt, D, is attached to the floor as shown and passed through the end of the lever, C. As the clamps sustain the spoke taut, it is only necessary to turn the nuts on the upright bolt against the lever and the latter is depressed. With this device, the No. 14 wire, 11 inch spokes, registered loads on the dial, E, from 425 to 480 pounds before breaking.

The next move was to test a cluster of wheels containing spokes made of same stock.

Fig. 2 is a sketch of the machine erected for the purpose of testing the strength of spokes in bicycle wheels. The device was set up in an apartment where room was plenty, and is, like the other devices used in these experiments, simply constructed, unpatented, and can be made and used by anyone interested in this line of work. The wheel to be tested is provided with a rather hard, solid tire, and arranged to be revolved by the wheel, A, the latter being driven by the belt, B; C is a speed indicator. A shaft, D, bears upon the capped journals of the shaft for the bicycle wheel, and this reaches up into the spring adjuster above, where it is held with nuts. The adjuster is provided with spiral springs, E E, also the wagon type of spring. A lever, F, is attached as shown, and the weights that pull down upon this lever determine the amount of

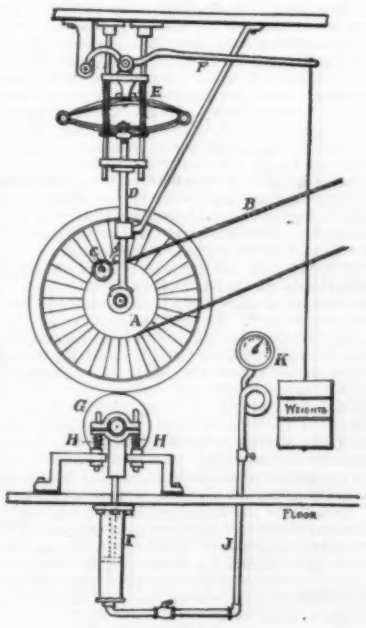


FIG. 2.

weight upon the wheel. A drum is set in bearings at G, and the wheel turns upon this. This drum is also provided with springs, H H, to modify the pressure. The proportion of pressure is known by means of an oil pressure dial, K. A cylinder, I, is placed where it receives the pressure of the drum by means of a plunger, and of course each vibration is transmitted through the pipe, J, to the dial, where the readings may be taken. Operated at a speed equal to about ten miles per hour, a number of wheels made as above described were tested, first with a weight calculated at twenty-three pounds upon each spoke belonging to the four spokes of the group in suspension, and which weight was increased to the breaking point. Twenty-three pounds was adopted, as that is what makers usually consider each spoke in a group in a wheel stands under favorable conditions. This weight was gradually increased to a load of over 200 pounds to each spoke in the group of four under pressure, under which weight some of the wheels from same makers both failed and succeeded. The marked contrast of sustaining power of wheels made under similar conditions at same shops, from same stock and on same lines, caused me to build another testing device, such

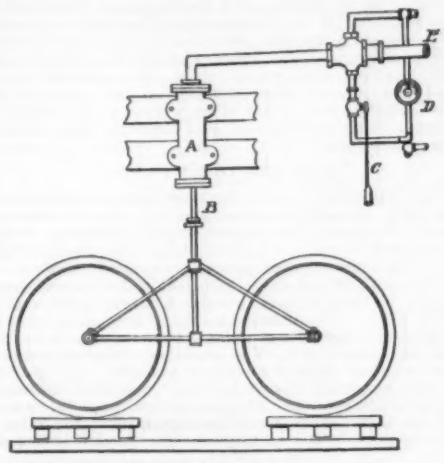


FIG. 3.

as shown in Fig. 3, for determining the strength of two wheels when arranged as in a bicycle frame.

Fig. 3 is an air pressure tester, in which two wheels are arranged in a frame made of strong tubing, and this frame is attached to the piston of the air cylinder, A. The air cylinder and all its connections can be purchased outright and set up as shown. The air supply can be obtained from a compressed air reservoir or air pump and the air passed into the pipe, E, and its pressure governed by the handle, C. The pressure gage is marked D. Any degree of pressure may be obtained. But the feature of the device is the manner in which the "drop" test can be obtained. By simply manipulating the handle the bicycle can be raised so as to effect a drop of one-half inch, one inch, two or more inches under specific loads. The drop test is very different from the uniform test. With this device a drop of one inch upon a solid base increased the stress to about 425 pounds upon each spoke of the four spokes in the group in service in each wheel, under which pressure, of course, no wheel could stand up. Under more favorable conditions, such as half inch drops, the variations in wheels of same construction were again noticed. Further experimenting convinced me that the variations were due to the system which it seems necessary to employ to true bicycle wheels.

I made a wood rim wheel, provided with a steel hub, and arranged as in Fig. 4. Here each spoke is cut in two and the ends linked to a small scale. The ends of the spokes that reach through the rim are fitted with adjusting threads and nut. In order to true this wheel I had to strain the spokes from 20 pounds to 190 pounds, as indicated, which variation of course weakened the wheel in general.

This variation exists more or less in most wheels, and my tests would seem to show that the greater the variation, the weaker the wheel. If some standard of strain for the spokes when truing wheels could be adopted, the wheels would be stronger. The custom of drawing untrue rims into shape by excessively straining one or more spokes in a group not only weakens that spoke, but also the others. We are in-

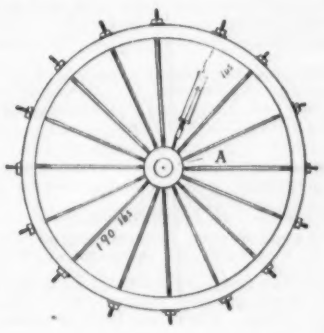


FIG. 4.

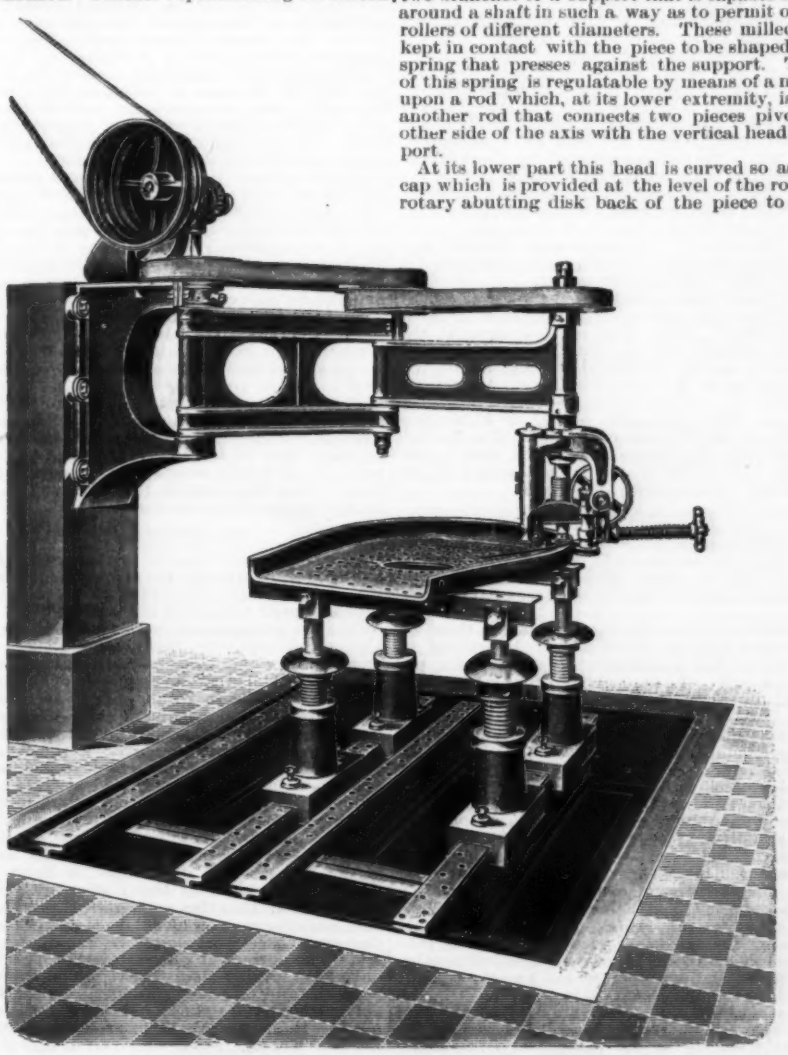
debted to The Hub for the above article by Mr. B. F. Fells. That journal has also kindly loaned us the cuts.

MACHINE FOR AUTOMATICALLY SHAPING THE EDGES OF IRON PLATES.

THE machine represented in the accompanying engraving, and devised by M. Paul Langbein, is designed for shaping the edges of iron plates used in the construction of fire boxes and the ends of boilers, as well as for profiling the sole bars of locomotives.

Its frame is provided with two jointed arms carrying pulleys which, through belts, set in motion the axis to which the shaping tool is fixed. From a bracket cast in a piece with the radial arm and traversed by the said axis is freely suspended, through a collar, a three-branched support capable of following any contour. Upon the axis there is an endless screw which gears with a wheel, the axle of which is received by the two lateral arms of the support. This axle is threaded here and there so as to actuate small wheels with helicoidal teeth keyed upon vertical axes each of which carries a roller with a milled edge. These axes are contiguous to the two branches of a support that is capable of revolving around a shaft in such a way as to permit of the use of rollers of different diameters. These milled rollers are kept in contact with the piece to be shaped by a spiral spring that presses against the support. The tension of this spring is regulatable by means of a nut screwed upon a rod which, at its lower extremity, is jointed to another rod that connects two pieces pivoted on the other side of the axis with the vertical head of the support.

At its lower part this head is curved so as to form a cap which is provided at the level of the rollers with a rotary abutting disk back of the piece to be shaped.



MACHINE FOR SHAPING IRON PLATE.

Under the pressure exerted by the spring, and by reason of their milled edges, the rollers force the entire apparatus to displace itself and follow the contours of the piece to be shaped.

The degree of advancement of the work depends directly upon the velocity with which the shaping tool revolves. The tool carrier follows straight lines as well as curves, since the cap and head, united by bolts, form a collar that may take freely any direction around the bracket. Upon the whole, when once the shaping tool has been put in place upon the object to be worked, it follows its outlines by reason of the automatic advance produced by the milled edged rollers.

Before starting the machine, the nut is unscrewed so as to loosen the spring and render it possible to introduce between the rollers the piece upon which has previously been traced the line to be followed by the shaping tool. Special arrangements are employed for the mounting of the objects to be shaped.

By means of four screw slides it is easy to place very horizontally the end of a locomotive fire box in order to shape the edge of it, as shown in the accompanying figure.

All that precedes refers to the use of a tool with a disk operating horizontally, but the same tool carrier is so arranged as to receive a cylindrical tool operating vertically.—Revue Industrielle.

[Continued from SUPPLEMENT, No. 1160, page 18544.]

ABSTRACT OF REPORT OF THE COMMISSIONER OF PATENTS FOR 1897.

THE DEVELOPMENT OF INDUSTRIES THROUGH PATENTED INVENTIONS.

PRIOR to January 1, 1881, 236,136 patents (not including 9,957 patents granted prior to 1836) were issued by the United States. These included all patented inventions exhibited at the Centennial Exposition at Philadelphia, an exposition of which the most striking and important feature was its display of the improvements in industrial arts brought about by American invention, a display which was a revelation to all who visited that exposition, and was justly attributed to the stimulus given to invention by the United States patent system. It was believed by many that the inventions there exhibited represented the highest development possible, that there was no further room for improvement in many of the arts at least. Yet the effect of this exposition was not, as might have been expected, to discourage invention and to convince inventors that nothing more remained to be done, that the field of invention was exhausted, but to largely simulate invention. For three years after this exposition the number of applications for patent received was less each year by fully one thousand than in 1876; but in 1880 the number was nearly two thousand more; in 1881 nearly five thousand more; in 1882 ten thousand more than in 1876 were received. Last year the number received was, by six thousand, more than twice the number received in 1876.

All of the inventions displayed at the Centennial Exposition and all of the inventions for which patents were taken out in the four years following 1876 are now public property. Included in these are inventions of the highest industrial and commercial value. The cotton gin, the sewing machine, the self-binding harvester, barbed wire fencing, the roller mill for flour milling, the sulphite paper process, the dynamo and the electric motor, important inventions in typewriters and the telephone, and many other inventions of almost equal effect in revolutionizing important industries are, in the form in which they were made and used prior to 1880, uncontrolled by patents, and may be freely made, used and sold by any one. Not only are these free to the public, but in the patents granted for these inventions, now expired, are contained explanations of the principles of these inventions and the best mode in which to construct and practice them. These patents are accessible to the public, and copies of them may be secured for a trifling sum. Improvements in these and other inventions made and patented since 1881 are for the most part still controlled by patents.

The influence of these inventions in the development of industries and the increase of employment of labor cannot be doubted. They had much to do with the increase of manufactures from 123,025 establishments, with aggregate capital of $543,245,351 and employing 958,079 persons, in 1850, the earliest census in which a distinct report on this subject is presented, to 253,502 establishments, with aggregate capital of $2,780,766,895, employing 2,700,732 persons, in 1880. The further increase to 322,638 establishments in 1890, with aggregate capital of $6,139,397,785 and employing 4,476,884 persons, is to be noted in this connection.

NEW INDUSTRIES.

But the influence of patented inventions is most strikingly shown in the creation of new industries of enormous magnitude since 1880—that is, within the term of patents now in force or but very recently expired.

Of these new industries the most noted are those directly connected with the development of electrical inventions, such as the manufacture of electrical apparatus and supplies, the supplying of electricity for lighting and power purposes, electric railways and the telephone.

The manufacture of electrical apparatus and supplies began to be of importance shortly before 1880, and in that year seventy-six establishments, employing 1,271 persons and producing an output valued at $2,655,036, were in existence. In 1890 the number of establishments had increased to 189, employing 9,485 persons and producing an output valued at $19,114,714. The increase in this industry has been very large since 1890. No separate statement of electrical machinery exported is given in the statistics of exports for that year. In 1897 the exports of such machinery amounted in value to $917,453. Besides this the exports of "instruments and apparatus for scientific purposes including telegraph, telephone and other electric" amounted in value in 1897 to $2,083,900, having increased to this amount from $88,383 in 1880 and $1,429,785 in 1890.

In the electric light and power industry as reported in 1880 there were but three establishments in the United States, employing 229 persons and producing an output valued at $458,400. In 1890 there were in the small portion of the country reported (the State of New York, the District of Columbia, and the city of St. Louis) 144 establishments, employing 2,004 persons and producing an output valued at $4,783,224. No statement of the extent of this industry in the whole country for the census year is available, but it is stated on what is believed to be good authority that in 1892 the aggregate capital invested in this industry in the United States was not less than $350,000,000. At the close of 1894 there were in the United States 2,124 central station supplying electricity for light and power and 7,475 isolated plants, a total of 9,599 establishments. The capital invested in these central stations is stated to have been $258,956,256, and the capital invested in the isolated plants, though not stated, was probably not below $200,000,000. A conservative estimate of the number of persons employed at that time in this industry would not be under 45,000. The growth of this industry since 1894 has been steady and rapid. New central stations and new isolated plants have been put in use all over the country, and those already in use have been enlarged. The prospect of still larger growth in the future is assured.

THE ELECTRIC RAILWAY.

The use of electricity for power purposes has found its most notable development in the electric railway. This is of very recent origin. The first electric street railway in the United States was put in operation little more than ten years ago. In 1880, of the 2,050 road miles of street railway in the United States, nearly all used animal power. Electric power was not then used. Steam and the cable were used on a few miles. The number of persons then employed on street railways was 11,087. The census of 1890 gives the number of street railway employes as 37,434. At the close of the year 1890 it is stated that the total mileage of street railways was 8,123 track miles, on 5,661 miles of which horses were used, the remaining 2,462 miles being mainly electric and cable. The capital invested in these roads was $211,277,795 and 71,000 persons were employed on them. In 1894 the total mileage was 12,527, of which 7,470 was electric. The capital invested was $648,330,755, of which $423,493,219 was invested in electric railways. One hundred and ten thousand persons were employed on street railways in that year. In 1896 the mileage had increased to 14,470, of which 12,133 miles were electric. The capital invested was $784,813,781, and the number of persons employed was not less than 140,000. The total mileage of electric railways in the United States up to October of 1897 was 13,765 miles, out of a total mileage of 15,718, of which but 947 miles were horse car lines. The total capital invested was $846,131,691. The number of employes may be safely estimated at not less than 166,000.

The electric railway is the best solution up to the present time of the question of rapid transit between suburban homes and the factory or place of business in the city. It has done much to solve the tenement house question and has brought into the market and made available for residence purposes large tracts of land which would otherwise be of little value.

THE TELEPHONE.

The telephone is now recognized as a necessity of commercial life. The manufacture of the instruments has up to a very recent date been in the hands of the company controlling the original patent. Since the expiration of that patent the manufacture of telephones has become a considerable industry; but no statement as to its extent is available. The telephone in 1880 was just beginning to become commercially known. At the close of 1896 there were in the United States 967 telephone exchanges, and 832 branch offices, using 536,845 miles of wire and employing 14,425 persons. The total amount stated to be invested in telephone property in 1895 was $77,500,000.

The investment in electric light and power plants, in electric railways and in the telephone represents to a very large extent money paid for labor, either directly for the construction of buildings and the construction of railway roadbed, the stringing of the hundreds of thousands of miles of wire, or indirectly for the manufacture of the materials and supplies necessary. The demand for copper, largely for electrical purposes, has caused the output to increase from 60,480,000 pounds in 1880 to 265,115,133 pounds in 1890, of which nearly all was produced in the United States. In 1895 the copper produced in the United States, including that made from imported pyrites, was 392,639,964 pounds, valued at $38,682,347. The demand for new cars for street railways has been enormous and has stimulated largely the manufacture of these cars. The needs of the street railways have led to the invention of new forms of fare registers, now very extensively used, and the manufacture of these fare registers forms in itself an industry of no inconsiderable proportions.

THE BICYCLE INDUSTRY.

Another industry hardly less important in its extent and in the opportunity for employment it has afforded is the bicycle industry. Though bicycles of a certain type, adapted rather for the athlete than the general public, were manufactured to a small extent in the United States in 1880, the industry was not of sufficient importance to require separate mention in the census statistics. The great development of the industry has come since 1890, as a result of the inventions in pneumatic tires made about that time; but it had grown in 1890 to be of considerable importance. In that year there were reported as engaged in the manufacture of bicycles 27 establishments, employing 1,925 workmen and producing an output valued at $2,568,326. In addition 83 establishments were engaged in the repair of cycles. These employed 306 persons and valued their product at $301,709.

In 1895 more than 200 establishments were engaged in the manufacture of cycles. In February of that year the president of the National Cycle Board of Trade stated that the aggregate capital employed in the manufacture of cycles exceeded $100,000,000 and that over 50,000 workmen were employed in this industry. The output of wheels for that year is stated to have been not less than 800,000. The industry to-day, notwithstanding an overproduction which has brought about a material reduction in price to the consumer, is not less than in 1895. The product in 1897 was over 1,000,000 wheels.

In 1880 a large proportion of the cycles used were imported, mainly from England. In 1897 the exports of cycles and parts of cycles to England amounted to a value of $2,128,491, and the total exports amounted to a value of $6,902,736.

Closely allied to the cycle industry are the manufacturing industries which supply to the cycle factory the materials used in the construction of the wheels. Steel tubing for the frame, chains for the driving gear, wood rims for the wheels, steel balls for the bearings, pneumatic tires, and saddles are all for the most part separately manufactured. New machinery for the manufacture of bicycle parts has been invented and is largely manufactured for use in this country and for export.

Saddles, bells, cyclometers, tools for bicyclists' use, lamps and locks for bicycles are all needed by those who use the wheel, and their manufacture requires the employment of thousands of workmen. The extent of the industry is indicated by the fact that a single company engaged in the manufacture of cyclometers claims to have sold 700,000 of these devices in a single year.

The sale of bicycles has become an important branch of trade. In 1895 no less than 1,400 concerns in the United States are named in a trade list, believed to be correct, as devoted exclusively to the sale of cycles and cycle supplies. Most of these employed, besides salesmen, one or more workmen for repairing. Besides these there were 848 shops making a business of repairing cycles. In addition to these, over 10,000 business houses carrying bicycles as part of their stock in trade are named in the trade list, and over 2,500 agents not having salesrooms.

THE TYPEWRITER.

Another new industry of great importance is the manufacture of the typewriter and typewriter supplies. There was no report for this industry in the census of 1880. In 1890, 30 establishments were reported, employing 1735 workmen and producing an output valued at $3,630,126. Since that year the industry has grown very largely in the number of workmen employed and the value of the product. In 1893 a single company employed 2,300 workmen. The exports of typewriting machines and parts for the past year amounted in value to $1,566,916. There is no reliable statement available as to the number of typewriting machines in use. It was estimated in 1895 that not less than 400,000 were then in use. One firm engaged in this industry published a statement more than a year ago that in 54 office buildings in New York City 3,426 typewriters were then in use. The use of the typewriter is practically universal among business houses and professional men. Agencies for the sale of typewriters, dealers in typewriter supplies, and schools for teaching the use of the typewriter are found in every city and large town throughout the land.

The great industrial value of the typewriter has been, however, in the employment it has afforded particularly to women. A bulletin of the Bureau of Education gives the number of schools teaching the use of the typewriter and its necessary accompaniment, stenography, in 1890 as 1,081, with 57,375 pupils, nearly all of them women. The census of 1890 reported that 33,418 persons were employed in the United States as stenographers and typewriters, of which 21,270 were women. In 1870 the census reported 154 shorthand writers in the United States, of which but 7 were women. The increase since the census of 1890 has been unquestionably very large, yet there is not to-day an oversupply of competent stenographers and typewriters, and they still command good wages.

AMATEUR PHOTOGRAPHY.

The manufacture of apparatus and materials for amateur photographers is another industry of large extent, practically new since 1880. The statistics of this industry are not given separately from those relating to the manufacture of apparatus and materials for professional photographers, an industry that was in existence long before 1880. In 1880, 15 establishments were engaged in the manufacture of photographic apparatus and materials, employing 169 persons and producing an output valued at $246,305. In 1890 the number of establishments was 70, employing 1,448 persons and producing an output valued at $2,745,729. The industry has grown very largely since 1890. In 1892 a single corporation engaged in the manufacture of apparatus and materials designed almost exclusively for amateurs had a capital of $5,000,000. Its capital in 1884 was $300,000. Cameras for amateurs in large variety and wide range of price are upon the market, each of them based on patented inventions of recent date. Dealers in such apparatus and materials are found everywhere, and though a statement of the present extent of the industry is not available, it cannot be doubted that it is very large.

These new industries have had a marked effect on the publishing industry. In 1880 there were in this country no journals devoted exclusively to electrical matters or to the bicycle, and two only, monthly publications of limited circulation, devoted to photography. In 1897 no less than 20 journals were devoted exclusively to electrical matters, 38 to bicycling and the bicycle industry, and 11, two of them weekly publications, to photographic interests, most of them largely devoted to the interests of amateurs. No journals devoted exclusively to typewriting are published, but to stenography, the necessary accompaniment of typewriting, 9 are devoted. Books by the hundred have been written and published on electrical matters and scores of them on photography, especially photography for amateurs. Not a few text books on stenography are published, while nearly every cycle manufacturer publishes for free distribution most elaborate and finely illustrated advertising catalogues.

CASH REGISTER AND CASH CARRIER.

Two industries of less extent, but of very considerable proportions, are the manufacture of the cash register and store service apparatus. Neither of these was in existence in 1880. In 1890, 5 establishments, employing 742 persons and producing an output valued at $1,281,500, are reported engaged in the manufacture of cash registers. In 1895 a single corporation engaged in this manufacture had a capital of $1,500,000, employed 1,700 men, and valued its product at $2,000,000. The aggregate number of cash registers in use at that time was stated to be 100,000, valued at $16,000,000.

The cash carrier industry has grown up mainly since

1890, the census of that year making no separate mention of this industry. No statement of its extent at the present time is available, but it is stated that in 1895 three of the leading companies in this industry had on rental in the United States not less than 30,000 cash carrier systems. Every department store in our cities, probably without exception, uses some form of cash carriers, and the manufacture of the apparatus employs hundreds of workmen.

BASIC STEEL.

Though no separate statistics are given for the basic steel process, by which steel free from phosphorus, and therefore capable of being worked cold, is produced, there can be no doubt that this process, invented not long prior to 1880 and first extensively used in that year, has had much to do with the large increase of the production of steel and in its use for tubing and structural purposes. The production of open hearth steel in 1880 was 100,851 tons; in 1890, 513,232 tons; and in 1896, 1,298,700 tons. A large proportion of this open hearth steel is basic steel.

The manufacture of iron and steel in 1880 employed 140,978 persons; its product was valued at $296,557,685. The same industry in 1890 employed 152,535 persons and its product was valued at $430,954,348. The manufacture from iron and steel of bolts, nuts, washers, and rivets, doors and shutters, forgings, nails and spikes, wrought pipe, and architectural and ornamental iron and steel employed, in 1880, 18,551 persons and produced a product valued at $39,391,906. In 1890 the same industries employed 59,694 persons and produced a product valued at $131,385,721. The exports of iron and steel, including manufactures of iron and steel, which in 1880 were valued at $15,133,493, increased to a value in 1890 of $25,592,208; in 1896 to a value of $48,670,218; and in 1897 to a value of $62,737,687.

ALUMINUM.

An industry which is growing in importance and which had no existence in 1880 is the manufacture of aluminum. This metal, which is daily finding new uses in the industrial arts, is now upon the market in large quantities at less than forty cents a pound. In 1896, 1,300,000 pounds of aluminum and aluminum alloys were produced in the United States, valued at $520,000. In 1880 this metal was a laboratory product, costly to produce, and not to be obtained for less than $10 to $15 a pound. In 1883, the first year in which aluminum is reported as a mineral product, the product is reported in troy ounces, not pounds. The product for that year was 1,000 troy ounces, valued at $875. It is produced to-day only by patented processes.

OTHER NEW INDUSTRIES.

Nor are these all of the new industries which have grown up in the period since in 1880. The graphophone, the kinetoscope, the half tone process of photoengraving, the chrome tanning process, smokeless powder and other high explosives, acetylene gas, linotype machines and automatic weighing machines all represent industries of very considerable importance in which millions of money are invested and many hundreds of men are employed. Many of these have been developed since the census of 1890, and no statement as to their precise extent is available. Others of earlier development are so interwoven with established industries that it is difficult to determine how much of the increase in employment and value of product is due to new inventions and what is due to normal growth of the industry.

The development of these new industries has not been at the expense of other industries as a whole. In few industries of importance was there a decrease in number of employes or in value of product from 1880 to 1890. In manufacturing industries as a whole the capital invested increased over 120 per cent. from 1880 to 1890, or from $2,780,766,895 to $6,139,397,785. The number of employes increased over 65 per cent., or from 2,700,732 to 4,476,884, and the value of product increased over 69 per cent., or from $5,349,191,458 to $9,056,764,996. The average yearly wages of employes, which in 1850 was but $247, increased to $429 in 1890.

It is to be noted with respect to the new industries based on patented inventions that none of them were immediately successful. The public is not quick to accept new inventions until their practical value has been amply demonstrated. The typewriter was not commercially a success until after long years of effort and the expenditure of a large amount of capital. The electric light was believed impracticable, and in its first installations was met by practical difficulties hard to be overcome. Only within a very few years has this light in either of its forms, the arc or the incandescent, become a light that could be depended on. Until within a very few years on those streets and in those buildings in which the electric light was used the fixtures for gas lights have been and are even yet retained, to be used in case the electric light fails. The cash register and the cash carrier met with serious opposition at first. It was years before the bicycle was made acceptable to the general public. The electric railway was accepted slowly, and its best type for city use, the conduit system, was first installed against the judgment of many of those believed to be best able to judge of its practical value. Even the telephone was at first believed, except by a few enthusiasts, to be nothing more than a toy.

None of the inventions on which these industries are based were in the form in which they were first patented commercially practicable. Even if it be conceivable that the primary inventions would have been made without the stimulus of the patent system, there would have been no inducement to inventors to spend time and money in perfecting and improving these inventions without the certainty that if made practicable and acceptable to the public their manufacture, use and sale could be controlled for a term of years through the protection afforded by patents. If a new device may be freely copied by rival manufacturers as soon as it appears upon the market, no one can afford to expend the large sums of money which are often found necessary in perfecting the invention, constructing the plant necessary for its manufacture, and bringing it before the public. It is stated that a new form of sewing machine for a special use cost in the preparation of dies and other machinery necessary for the economical manufacture of its parts upward of $50,000 before a single machine was ready for sale. But for the fact that the manufacturers had the assurance of an exclusive right to manufacture this machine through their ownership of the patents granted for the inventions which it embodied no such sum could have been expended, and the public would have had to be content with the inferior machines previously on the market.

The cost of taking out the patents relating to the several industries above considered is in the aggregate a large sum. Since 1880 the number of patents granted relating to electrical matters is 28,457; relating to bicycles, 3,196; to typewriters, 1,410; to photography, 1,293. The Patent Office fees on each patent issued are $35. The attorneys' fees for preparation and prosecution of the application may be reckoned at $50. The aggregate thus expended is, for office fees, $1,202,460; for attorneys' fees, $1,717,800; or $2,920,260 in all. Besides this an amount fully as much more was doubtless expended in time and money by the inventors experimenting and perfecting their inventions before they were ready to patent.

Inventors cannot be expected to expend such an amount of money through a disinterested desire to benefit the public nor can manufacturers be expected to invest vast sums of money in the manufacture of new devices which may not prove acceptable to the public if rival manufacturers who have risked nothing are to share equally in the possible profits. It is only by "securing for limited times . . . to inventors the exclusive right to their respective . . . discoveries," as was fully recognized by the framers of the constitution, that their aid in promoting "the progress of the useful arts" can be secured.

To the stimulus afforded by the Patent Office is due the creation of these new industries and the very great development of recent years in the older industries. It is to the stimulus to invention given by our patent system that the great increase in our exports is largely due, and it is on American invention, as fostered and stimulated by the patent system, that we may confidently depend for ability to maintain the high rates of wages paid to American workmen and yet compete successfully in the markets of the world with nations where the workman receives but a meager return for his labor.

Respectfully submitted,
A. P. GREELEY, Acting Commissioner.

THE ANNEALING OF COPPER.

By G. WYCKOFF CUMMINS.

COPPER is at present almost universally annealed in muffles, in which it is raised to the desired temperature and subsequently allowed to cool either in the air or in water. It may be stated for the benefit of those not versed in the practical work of annealing that a muffle is nothing more or less than a reverberatory furnace. It is necessary to watch the copper carefully, so that when it has reached the right temperature it may be drawn from the muffle and allowed to cool. This is extremely important, for it is found that if the copper is heated to too high a temperature, or is left in the muffle at the ordinary temperature of annealing for too long a time, it is "burnt" as the workmen say. Copper that has been "burnt" is yellow, coarsely granular and exceedingly brittle—so much so that in some samples in my possession it cannot be bent once at a right angle without breaking. It is even more brittle at a red heat than when cold.

In the case of coarse wire it is found that only the surface is "burnt," while the interior is damaged to a far less extent. This causes the exterior to split loose from the interior when bent or when rolled, thus giving the appearance of a brittle copper tube with a copper wire snugly fitted into it. Cracks a half inch in depth have been observed on the surface of an ingot on its first pass through the rolls, all due to this exterior "burning." It is quite apparent that copper that has been thus overheated in the muffle is entirely unfit for rolling, either for rods or sheet copper or for wire drawing. It is found that the purer forms of copper are far less liable to be harmed by overheating than samples containing even a small amount of impurities. Even the ordinary heating in a muffle will often suffice to "burn" in this manner the surface of some specimens of copper, and thus render them entirely unfit for further working. The explanation of this will be made later. Copper that has been thus ruined is of use only to be refined again.

As may be inferred from the above, only the highest grades of refined copper are at present used for drawing or for rolling. This is not because the lower grades, when refined, cannot stand sufficiently high tests, but because the present methods of working are not adequate to prevent these grades of copper from experiencing the deterioration due to overheating. This is unfortunate for the manufacturer, since, I understand, he has to pay cash in advance for the highest grades of refined copper.

In order better to appreciate the explanation of the various phenomena of copper annealing, let us see what refined copper is. The process of refining copper consists in an oxidizing action followed by a reducing action which, since it is performed by the aid of gases generated by stirring the melted copper with a pole, is called poling. The object of the oxidation is to oxidize and either volatilize or turn to slag all the impurities contained in the copper. This procedure is materially aided by the fact that the suboxide of copper is freely soluble in metallic copper and thus penetrates to all parts of the copper, and, parting with its oxygen, oxidizes the impurities. The object of the reducing part of the refining process is to change the excess of the suboxide of copper to metallic copper. Copper containing even less than one per cent. of the suboxide of copper shows decreased malleability and ductility and is both cold short and red short. If the copper to be refined contains any impurities such as arsenic or antimony, it is well not to remove too much of the oxygen in the refining process. If this is done, "overpoled" copper is produced. In this condition it is brittle, granular, of a shiny yellow color, and more red short than cold short. When the refining has been properly done and neither too much nor too little oxygen is present, the copper is in the condition of "tough pitch" and is in a fit state to be worked.

"Copper is said to be tough pitch when it requires frequent bendings to break it, and when, after it is broken, the color is pale red, the fracture has a silky luster, and is fibrous like a tuft of silk." On hammering a piece to a thin plate it should show no cracks at the edge. At tough pitch, copper offers the highest degree of malleability and ductility of which a given specimen is capable. This is the condition in which refined copper occurs in the market, and if it could be worked without changing this tough pitch, any specimen of copper that could be brought to this condition would be suitable for rolling or drawing. We have seen that tough pitch is changed if we either add oxygen to or take oxygen from refined copper.

By far the more important of these is the removal of oxygen, especially from those specimens that contain more than a mere trace of impurities. This is shown by the absolutely worthless condition of overpoled copper. The addition of carbon also plays a very important part in the production of overpoled copper.

That the addition of oxygen to refined copper is not so damaging is shown by the fact that at present nearly all the copper that is worked is considerably oxidized at some stage of the process, and not especially to its detriment.

Let us see how the above facts are related to the process of annealing copper. I have already referred to what is known as "burnt copper." This you may already have recognized as nothing more nor less than copper in the overpoled condition. This is brought about by the action of reducing gases in the muffle. By this means the small amount of oxygen necessary to give the copper its tough pitch is removed. You must remember that this oxygen is combined with impurities in the copper, and thus renders them inert. For example, as explained by Dr. Peters, the oxide of arsenic or antimony is incapable of combining more than mechanically with the copper, but when its oxygen is removed, the arsenic or antimony is left free to combine with the copper. This forms a very brittle alloy, and one that corresponds almost exactly in its properties to overpoled copper. To be sure, overpoled copper is supposed to contain carbon, but that this is not the essential ruining principle in case of annealing is shown by the fact that pure copper does not undergo this change under conditions that ruin impure copper, and also by the fact that the same state may be produced by annealing in pure hydrogen and thus removing the oxygen that renders the arsenic or antimony inert. No attempt is made to deny the well known fact that carbon does combine with copper to the extent of 0·2 per cent. and cause it to become exceedingly brittle. It is simply claimed that this is probably not what occurs in the production of so-called burnt copper during annealing. The amount of impurities capable of rendering copper easily "burnt" is exceedingly small. This may be better appreciated when it is considered that from 0·01 to 0·2 per cent. expresses the amount of oxygen necessary to render the impurities inert. The removal of this very small amount of oxygen, which is often so small as to be almost within the limits of the errors of analysis, will suffice to render copper overpoled and ruin it for any use.

Perhaps the most interesting part of this article, to practical men at least, will be the description of a method of avoiding the numerous accidents that may occur in the annealing of copper, due to a change of pitch. As already pointed out, the quality of refined copper is lowered if oxygen be either added to or taken from it. It is quite apparent, therefore, that a really good method of annealing copper will prevent any change in the state of oxidation. To accomplish this it is necessary to prevent access to the heated copper both of atmospheric air, which would oxidize it, and of the reducing gases used in heating the muffle, which would take oxygen away from it. Obviously the only way of accomplishing this is to inclose the copper when heated and till cool in an atmosphere that can neither oxidize nor deoxidize copper. I find that by so doing copper may be heated to the melting point and allowed to cool again without suffering at all as regards its pitch. There are comparatively few gases that can be used for this purpose, but, fortunately, one which is exceedingly cheap and universally prevalent fulfills all requirements, viz., steam. In order to apply, then, in practice the principles already enunciated, it is necessary only to anneal copper in the ordinary annealing pots such as are used for iron; care being taken to inclose the copper while heating and while cooling in an atmosphere of steam. This will effectually exclude air and prevent the ingress of gases used in heating the annealer. Twenty-four hours may be used in the process, as in the annealing of iron wire, with no detriment to the wire. This may seem incredible to those manufacturers who have tried to anneal copper wire after the manner of annealing iron wire. By this method perfectly bright annealed wire may be produced. Such a process of annealing copper offers many advantages. It allows one to use a grade of copper that has hitherto been worked only at a great disadvantage, owing to the ease with which it gets out of pitch. It allows one to use annealers such as are ordinarily used for annealing iron, and thus cheapens the annealing considerably as compared with the present universal use of muffles. There is no chance of producing the overpoled condition from the action of reducing gases used in heating the muffles. There is no chance of producing the underpoled condition due to the absorption of suboxide of copper. None of the metal is lost as scale, and the saving that is thus effected amounts to a considerable percentage of the total value of the copper. The expense and time of cleaning are wholly saved. Incidentally bright annealed copper is produced by a process which is applicable to copper of any shape, size or condition—a product that has hitherto been obtained only by processes (mostly secret) which are too cumbersome and too expensive for extensive use; and, as is the case with at least one process with which the author is acquainted, with the danger of producing the overpoled condition, often in only a small section of the wire, but thus ruining the whole piece.

If it is desired, the copper may be annealed in an apparatus so arranged that the copper when heated may be dropped into a body of water without access of air, and thus make a far smaller annealing plant suffice. It may be mentioned that copper seems to be made neither softer nor harder by being cooled suddenly in this manner than if cooled slowly, though some of the alloys of copper are rendered somewhat softer by a sudden cooling; in fact, there is not the

slightest evidence anywhere to justify the quite prevalent belief that an art of hardening copper was known to the ancients. The hardest tools of the ancients were made of bronze, not copper.

By application of the same principles it is possible to prevent both deoxidation and oxidation, in the heating of copper ingots for the rolls, and thus, by keeping copper at tough pitch all along, any copper that can be given tough pitch can be used for rolling as sheet copper or for wire.

I think it also practicable to produce bright copper rods direct from the rolls.

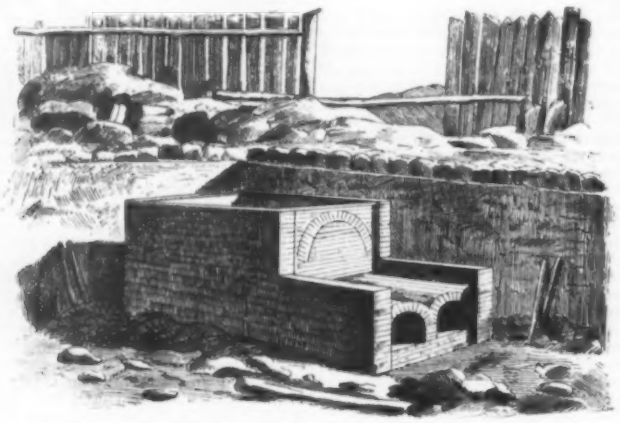
BERNARD PALISSY AND HIS ART.

THERE are few of the arts in which sentiment has not played some part at some time, and the noble art of ceramics has had more than its share. The thread of romance which ran all through the potter's art is nowhere more pronounced than in the case of Bernard Palissy, whose whole life reads like a fiction. He was born in 1510 at La Chapelle Biron, a village in the province of Périgord, France. His parents were poor, and at an early age he was thrown on his own resources with an elementary education, but he set to work reading all the books within his reach, and aided by remarkable powers of observation, he soon gained a knowledge of chemistry, geology, botany and other branches of natural science. His father was a painter in stained glass and taught his son the practice of this art. The latter soon became a skillful draughtsman and learned the manipulation of colors, which was a great assistance in his after career as a potter. Young Palissy traveled for a while, then married and settled at Saintes, where he practiced his trade of glass painter, eking out his meager income by portrait painting and land surveying.

He happened to see one day a piece of enameled pottery, probably majolica from Italy, and he at once resolved to spend any time and labor to discover for himself the secret of the beautiful enameled surface, which he so much admired. He already knew a great deal about painting and firing with enameled colors. He had also learned the rudiments of the potter's art, but he knew nothing whatever of the manufacture of the finer varieties of the faience or of the composition of the white enamel. Year after year he bravely experimented, but his efforts only ended in a succession of failures, but he struggled blindly on in search of the secret of the white enamel. He and his family were almost in rags; his wife reproached him bitterly; he even destroyed his furniture to feed his greedy kilns. For nearly sixteen years he carried on a tragic struggle before success finally came, and the results at last were only what every potter in Northern Italy had known for years. He might have saved all the expense and the best years of his life, which he had wasted in his useless experiments, if he had only known that he could have obtained the process in Northern Italy. These struggles and failures are most vividly told by Palissy, himself in one of the most thrilling autobiographies which has ever been written, an autobiography which is comparable with that of the Florentine Cellini, his contemporary.

Now success smiled on Palissy, and he enjoyed the reward for his years of trial and constancy of purpose. His works were bought and appreciated by the Queen Catherine de' Medici, and many of the nobles of the court were anxious to obtain specimens of his skill. Unfortunately for him, Palissy became enthralled by the new doctrines of the Reformation and he enrolled himself as an enthusiastic member of the Huguenot party. In 1558, while engaged in the manufacture of his faience, he was arrested and imprisoned at Bordeaux, where his kilns were destroyed by command of the magistrates. Through the intervention of the French court Palissy was liberated, and in 1563 under the protection of the king he set up his kilns on a plot of ground occupied by the gardens of the Tuileries. In 1865 this kiln was discovered; it is shown in our engraving. Palissy lived and worked at the court in comparative peace and prosperity until 1588, when the outburst against the Huguenots proved too strong even for royal patronage. He was imprisoned in the Bastile and Henry III. was too weak to save the man who for forty-five years had faithfully served the court of France. Palissy was condemned to death, but died in 1589 before the sentence was carried out, in one of the dungeons of the Bastile. This martyr's death was the fitting end to the life of a man whose whole career had been one of self-sacrifice in the cause of art.

Palissy's pottery is for the most part executed after one process. Hard, well burnt earthenware was covered with a white enamel formed of the usual ingredients of glass with the addition of oxide of tin. On this white ground various colors were applied in enameled pigments and the whole finally covered with a thin lead vitreous glaze. Palissy used the potters' wheel but little, aiming less at purity and beauty of the outline than at elaborate surface decoration in high relief, formed by pressing the clay into a mould. The best known reproductions of Palissy's art are large plates, ewers, vases, etc., decorated in relief with realistic figures, as reptiles, fish, insects, shells, plants and other objects executed from moulds formed by taking casts of the objects themselves. Palissy took the greatest delight in reproducing every scale on all insect or fish's backs and the minutest peculiarity of a fossil shell. The casts from the various objects were fixed on a dish or vase of the shape required, and a fresh cast from the whole formed a mould from which Palissy could reproduce many articles of the same kind. After being covered with the white enamel the various parts of the piece were painted in realistic colors which were as near truth as could be reached by the pigments Palissy was able to discover and prepare. The colors were mostly shades of blue with some crude greens, browns and grays and rarely yellow. Other pieces were ornamented with figure compositions, generally scriptural scenes. Geometrical designs were also used by Palissy, and these were perhaps his most successful though not his most celebrated works. On the whole, his productions cannot be ranked very high as works of art, though they are very curious and are marvels of ingenious skill. The examples of his work are highly valued, and the imitations are not very good. As an author Palissy was even more successful than as a potter. A high position among French writers was assigned to him by Lamartine. He wrote on a great variety of subjects, including architecture, natural philosophy and literature.



FURNACE OF BERNARD PALISSY FOUND IN THE TUILERIES, PARIS, IN 1865.

PERRAULT'S COLONNADE OF THE LOUVRE.

THE Louvre is emphatically the most important public building of Paris, both from an architectural point of view and on account of its historical associations. It is a palace of vast extent rising between the Rue de Rivoli and the Seine. It derives its name from an ancient hunting château once situated in the midst of a forest infested by wolves, whence the name "Louverie" or "Louvre." We shall not trace the interesting history of the edifice, but shall confine ourselves to its crowning glory, the colonnade, by Claude Perrault, 1665–1670. This façade is 570 feet long and 90 feet high and is the classic example of a colonnade, and is one of the most remarkable conceptions of modern architecture.

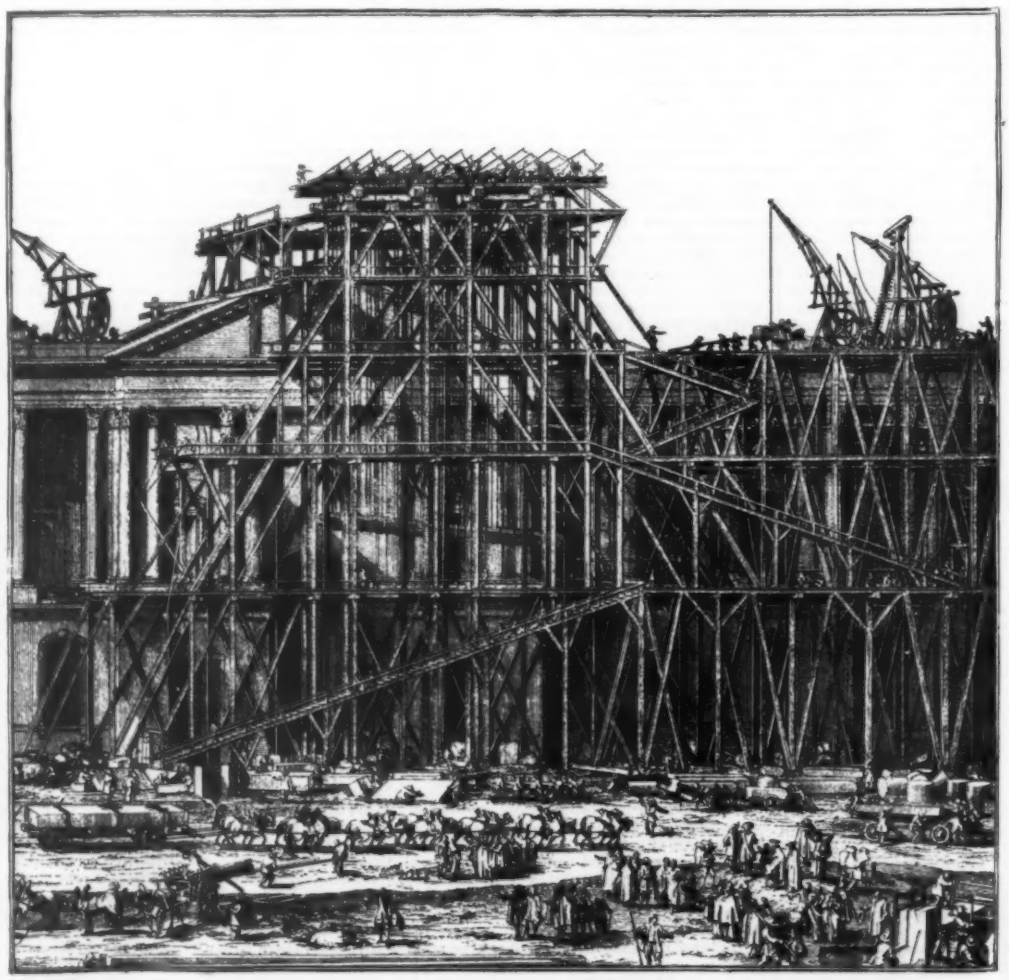
In 1664 Colbert became Superintendent of Buildings and the façade did not seem to be worthy of the royal edifice, so a wooden and plaster model was made of it, and this was exposed to the criticism of competent persons. Then a competition was held and various architects were asked to compete. Among the plans submitted were those of Claude Perrault, a doctor. Colbert was delighted with those of the latter, but before coming to a decision he sent the designs of all except Perrault to the painter Nicolas Poussin, at Rome. The artist returned all the plans with severe criticisms and sent plans of his own that were not acceptable to either Colbert or the king. Colbert now wished to give the commission to Perrault, but the Abbé Benedetti and Cardinal Chigi, afterward Pope Alexander VII., urged him to engage the services of that second-rate architect of the Roccoco, Bernini. The Italian came from Rome and submitted his usual florid designs, which were, fortunately, not accepted. He afterward retired with a pension, vexed by the jealousies of the French architects. Colbert hesitated no longer, and ordered Perrault to begin the work at once. The first stone was laid by Louis XIV. with great ceremony, two medals being struck on the occasion, on October 17, 1665, and the new façade was finished in 1670.

Though the splendid Greco-Roman front to the French Renaissance building is a monument of noble and incontestable grandeur, still the influence on the older part of the Louvre is regrettable, as every attempt was made to make the older portions of the building harmonize with the façade. The original design of Perrault was more florid than that which was actually executed. Perrault refused the title of "first architect," but accepted the pensions which were bestowed on him as "doctor and savant." Our engraving is taken from an old print by Leclere, 1677, and shows the great scaffolds and the arrangement of a gang of cranes which were used to raise the two great monoliths for the front. There appears to be not less than fifteen of these drum cranes in use in raising the great stone. It is an excellent example of the difficulties which beset builders before the days of steam power, and we may well be astonished when we consider the monoliths and obelisks which they transported and erected, seemingly with almost as much ease as we would do to-day, and certainly with as much success.

THE MANUFACTURE OF OXYGEN.

THE daily increasing development that the applications of oxygen are assuming leads us to give herewith a short historical study of the manufacture of this product, as well as an account of the present state of a very recent industry that has sprung from it.

There are two inexhaustible sources of oxygen offered to us, and these are water and air. Water contains eight-ninths of its weight in oxygen, combined with one part of hydrogen. So it was this compound that the industry first took up. It will be remembered, in fact, that the Alliance Society was formed for the



BUILDING PERRAULT'S COLONNADE OF THE LOUVRE, PARIS, 1665–1670.

exploitation of an illuminating gas produced by the electrolysis of water by means of Abbot Noliet's magneto-electric machine.

Let us see, then, what would be the work requisite to produce one cubic meter of oxygen (or 1·43 kilogrammes of the gas) in this way.

The combustion of 8 kilogrammes of oxygen with 1 kilogramme of hydrogen disengages, according to Favre and Silbermann, 34,462 heat units; 1·43 kilogrammes of oxygen will disengage 6,160 heat units; and the corresponding work in horse power in one hour will be

$$\frac{6{,}160 \times 425}{75 \times 3{,}600} = 10 \text{ H.}$$

But in practice such useful work will be augmented by the resistance of the machine, by the conductors, by the electrolyte and by the polarization of the electrodes —all of which are causes that, under the form of sensible heat, will absorb a notable part of the electric energy furnished.

Nevertheless, a few experiments have been made in this direction, and recently there has been some talk about an industrial process based upon electrolysis and devised by Pompeo Garruti, an Italian. The basis of this invention is a voltameter of which the conception seems to us very odd, but which at Naples is said to have given the most remarkable results. On another hand, it is asserted that, after being carried at great expense to Brussels, it totally failed to keep any of its promises. Can it be possible that it is in Italy only that a person is a prophet in his own country? However this may be, the question on this side has made scarcely any advance toward solution, owing to the difficulties that are experienced in the separation of the oxygen and hydrogen and the considerable amount of energy necessitated by the electrolysis. As air is not, as water is, a combination, it would seem, a priori, that some mechanical means might effect an easy separation of the elements of which it is composed. Unfortunately, the physical properties of oxygen and nitrogen are too similar to allow this to be the case.

An effort has been made, nevertheless, to utilize the difference in their osmotic properties and their solubility. A German manufacturer proposed to separate the oxygen from the nitrogen through the evaporation of the latter from a mass of liquefied air. In this he somewhat approached the conceptions of Jules Verne. There is nothing practical in all this for the manufacture of pure oxygen. Up to the present, there has been but one method that has been successful, and that is the one that consists in causing the oxygen of the air to enter into a combination that it is easy to dissociate afterward. It is therefore a chemical method.

At the beginning of the year 1884, chemists had bequeathed to us two interesting processes, that of Boussingault and that of Tessié du Motay and Maréchale, the Mallet process, which was never applied, being left out of the question.

The Boussingault process consisted in dissociating, at a red heat, binoxide of barium formed by the direct oxidation of caustic barytes, toward 500°. Dumas' learned fellow laborer had, however, found that, at the temperature of a bright red heat, barytes quickly lost the property of oxidizing, in consequence of the modifications introduced into its structure by this elevated temperature. So the industrial trials of this process gave no practical result.

Toward the end of 1884 Boussingault introduced an important modification into his original process. He discovered that the dissociation of binoxide of barium was possible at a temperature slightly above dark red, provided that the substance were placed in a vacuum. In thus diminishing the pressure necessary for the disengagement of the oxygen, it was possible to utilize a tension of dissociation corresponding to a relatively moderate temperature. Under such circumstances the power of absorption of the barytes for the oxygen of the air was capable of maintaining itself for a very long time in its integrity. Let us see what the value of this new process was. Its realization is easy, its rendering good, and the operation is easily performed. Unfortunately, it does not give pure gas in a regular manner, on account of the vacuum. It is very difficult, in fact, to maintain absolute tightness in a long and complicated conduit formed of numerous joints and submitted to frequent alternations of expansion and contraction under the action of variations in the temperature. Moreover, a leak in piping submitted to a vacuum is difficult to stop. The result is a variable and almost continuous suction of air, which becomes mixed with the oxygen produced. But what is to follow is graver still, by reason of the development that the use of oxygen in therapeutics is daily assuming.

As well known, metals, particularly cast iron, raised to a red heat, become porous and permeable to gases. Under such circumstances, the retorts submitted to a vacuum allow of the passage of a portion of the furnace gases through their sides. The carbonic acid fixes itself in part upon the barytes, which it gradually renders inactive, but the incompletely burned carbonic oxide is drawn into the current of oxygen, especially toward the end of the operation. Finally, if the vacuum pump be lubricated with oil, the oxygen that it sends to the gasometer will be contaminated with carburets.

There was, therefore, some better process needed, and this was found by Messrs. Dutremblay and Lugan, who are successfully exploiting it at their works at Boulogne-sur-Seine, which were built about two years ago.

It was the process of Tessié du Motay and Marechale that they took as a basis for the study which has resulted in their present method of manufacture.

The principle of this process, as we know, is as follows: If a current of pure and dry air be made to pass over a mixture of soda and binoxide of manganese heated to about 450°, the oxygen will be absorbed and manganate of soda will be formed. If, without changing the temperature, a current of superheated steam be passed over this manganate, the primitive elements of the mixture will be regenerated, with a disengagement of the oxygen that they have absorbed. It will be seen that, as in the Boussingault process, the chemical raw material is theoretically non-usable.

The immense advantage of this process is evident. As all the conduits, as well as the retorts, are constantly under the pressure of air or steam, no suction of air from the exterior or of gases from the furnace can take place. If, then, at the moment of the emission of the oxygen, the latter be sent to the gasometer only after all the dead space of the piping has been well cleared, there will be no difficulty in obtaining chemically pure gas. In practice, the clearing of the pipes is not perfect, and the steam contains a portion of the nitrogen that was in solution in the feed water of the generator. This makes the composition of the gas collected 95 per cent. pure oxygen and 5 per cent. harmless nitrogen. This gas, which may be considered as practically pure, and which is the best that the industry has ever produced up to the present, is perfect for all uses, and particularly for medical purposes.

We shall, in a few words, describe the apparatus used in this process in the Boulogne works, the production of which is capable of reaching 100 cubic meters in twenty-four hours.

An air pump without any dead spaces sends 3 cubic meters of air per minute to the retorts through a horizontal purifier, which contains a chemical substance designed to absorb the humidity and the carbonic acid (Fig. 2). The vertical cast iron retorts are situated in two heating chambers supplied by an intermediate combustion chamber in which hot air burns the inflammable gases formed in a generating furnace. These retorts, which contain the manganates, receive air and steam alternately through the intermedium of an automatic distributer (Fig. 1). This latter consists of balanced valves actuated by the compressed air that is sent to them by electric distributers. A brush having a circular motion sends the current periodically into the distributers. The valves that receive the pure oxygen direct it toward a gasometer of 100 cubic meters capacity through a refrigeratory supplied by a thermosiphon designed to condense the steam that accompanies the gas. This latter (absolutely free from carbon in the form either of oxide or carburet) is compressed to 120 atmospheres in steel tubes, in measure as it is called for.

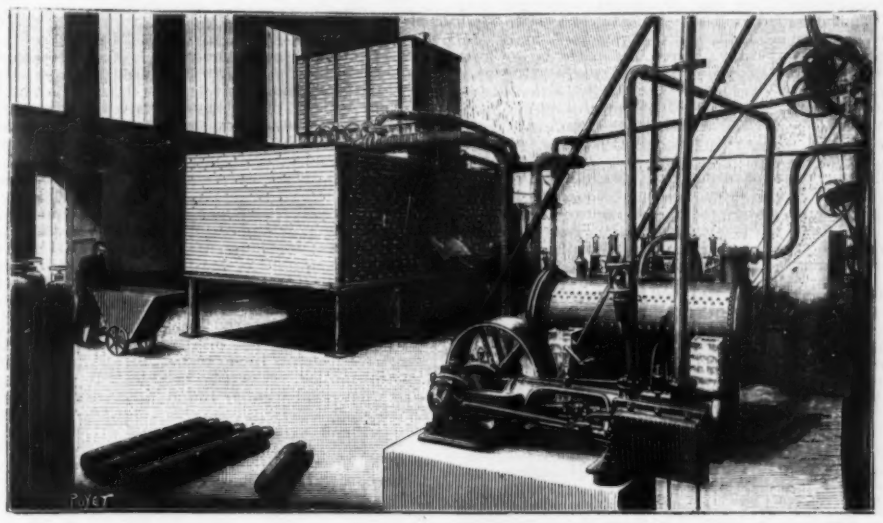


FIG. 2.—GENERAL VIEW OF THE OXYGEN MANUFACTORY OF BOULOGNE-SUR-SEINE.

These tubes, which are of drawn steel and without seams, are extremely light notwithstanding their strength. They are tested to a hydraulic pressure of 300 atmospheres and are charged at a pressure of 120.

They are inexplosible and were put to a test at the fire of the Charity Bazar. One of them, raised during the fire to a temperature higher than 1,000°, became inflated under the influence of the great internal pressure, and finally allowed of the escape of the harmless gas that it contained, through a small fissure that formed near the base, without the projection of the least particle of metal. The charge of these tubes is controlled by special pressure gages, the construction of which prevents any danger of explosion.

The oxygen is compressed in the tubes by means of a compound compressor, with a cooling of the gas at each cascade (Fig. 3). The gas may be directly extracted from it without recourse being had to a special expander, which is always expensive and never operates perfectly. To this effect, Messrs. Dutremblay and Lugan have devised a micrometric screw, which is adjusted upon the tube and permits the oxygen to make its exit under as feeble a pressure as may be desired.

For the above details and the figures we are indebted to La Nature.

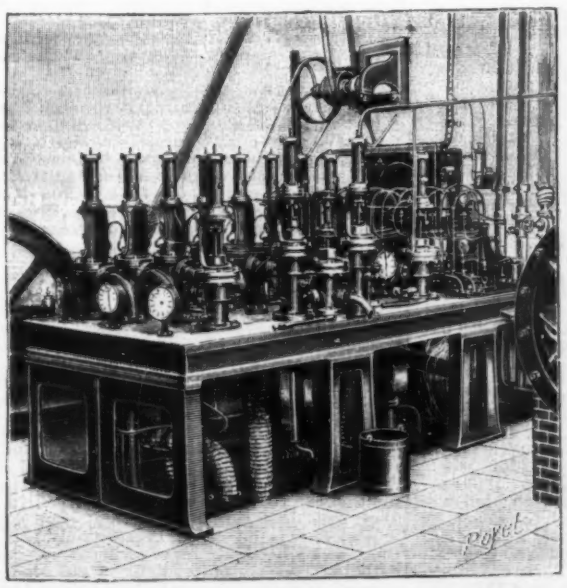


FIG. 1.—AUTOMATIC DISTRIBUTER WITH BALANCED VALVES, OPERATED ELECTRICALLY.

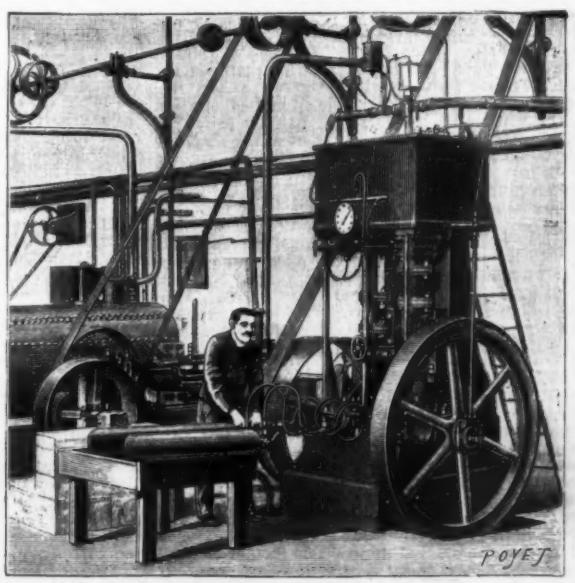


FIG. 3.—COMPOUND COMPRESSOR IN WHICH THE GAS IS COOLED AT EVERY CASCADE.

ENGINEERING NOTES.

The increase in the shipping of Hamburg shows very clearly in the number and total tonnage of ships arriving at that seaport:

	Number of ships.	Tonnage.
1895	9,443	6,254,000
1896	10,477	6,445,000
1897	11,173	6,708,000

In 1896, 395 ships, with 878,000 tons, arrived from the United States; in 1897, 517 ships, with 1,158,000 tons. Most of the arrivals in 1897 were steamers, viz., 7,837 ships, with 6,036,000 tons; the tonnage of sailing vessels amounted to only 672,000.—Uhland's Wochenschrift.

It is announced that Herr Wachnitz, a German engineer, has succeeded in plating aluminum with copper by a welding process, says Industries and Iron. It is stated that the plated sheets can easily be soldered, grooved, tinned and nickeled. The plating may be of any thickness desired, and even with the thinnest sheets there is no separation when rolled or drawn. Large sample sheets have already been submitted to the inspection of the Imperial Navy Department and other large manufacturing concerns. The obstacles to a still wider use of aluminum, which could be expected in view of its great lightness, have been its poor ability to solder, weak power of resistance to numerous fluids, and the further fact that paint does not adhere to it very well. All these objections would be removed by this invention.

The concrete dome of the law library, Columbia University, presents a number of interesting engineering problems in both design and construction. Before commencing to build the dome the contractors, Messrs. Norcross Brothers, made a number of interesting tests with concrete. A ring of 6 inches by 6·5 inches angle iron, 15 feet in diameter, was used as a horizontal circular tie, within which a flat dome of concrete was built. The concrete was 6 inches throughout, and was formed of four parts of stone, two of sand, and one of Portland cement. The dome rose 6·44 inches in the center, and it stood covered with 2 inches of damp sand for fifty-eight days after it was completed. A bed of sand was then laid over it to support a circular platform 5 feet in diameter. About 60,000 lb. of bricks were laid on the platform before any deflection could be detected, and 80,000 lb. were supported for six days without any sign of failure becoming apparent. It was intended to test the dome to destruction, but more than 80,000 lb. could not be applied without danger to the men conducting the experiment.

A committee of experts, who have recently conducted extensive tests under the auspices of the Philadelphia Fire Department to determine the relative merits of the piston and rotary types of fire engines, have reported in favor of the piston as the most effective, economical and enduring. The conclusions reached, says The Iron Age, are summed up in the report as follows: 1. That both engines were handled with fidelity and ability by the men in charge. 2. That both would endure hard work better if all the joints about steam cylinders and various connections were either ground or made of copper instead of rubber. 3. Neither engine seems large enough or so substantially built as to stand the hard and continuous service that should be required at a fire in the business portion of the city, though, owing to the lightness of the engines, they may be suitable for suburban work. 4. The piston type is undoubtedly the most economical, effective and enduring machine of the two engines tested. This test points to the necessity of similar trials being made prior to the purchase of additional engines by the department, if such course be at any time decided upon.

Some of the Western railroads are making extensive use, as ballast for their tracks, of gumbo, a sort of clay found in large quantities in that part of the country, and declared to be the best possible material for that purpose after having been burned. With this in view, a track is laid in a field, sometimes a mile long, and, moving along this track, immense steam shovels take up the clay from the trenches on either side; a bed of old ties and other inflammable stuff laid along the intended trenches is covered with about one foot of the gumbo; then follows a covering of fine coal, which is spread over the gumbo several inches thick, the steam shovels again traveling the entire length of the kiln, throwing up on top of the coal another foot of the raw gumbo. This process continues over and over again, the trenches getting deeper and deeper and the kiln higher, until a depth of 10 or 12 feet is attained. At this stage the savings and kindlings which have been placed between the old ties are set on fire, and the burning continues until the material takes on a bright red color, when it is in the proper condition to be used for ballasting. Gumbo also prevents the growth of weeds.

The "schlamm," or mud, thrown down from the water of coal washing has hitherto been regarded as worthless, says The Engineering and Mining Journal, except that sometimes a portion of the coal particles it contained have been separated and made of value by a washing process; but Bergassessor Haarmann, of Friedrichsthal, has invented a new method for treating it dry and dividing it into two products, one of which, with low ash content, is distinguished by its granular nature, while the other contains a large proportion of ash and is of the fineness of flour. The former of these two products is, on account of its low ash content, useful for various purposes, and the latter constitutes a fuel quite ready for use in coal dust firing. The method is founded on the circumstances, hitherto lost sight of, that the incombustible constituents of the "schlamm" chiefly consist of clay which was formerly more or less dissolved in the wash water; and, on the mud being dried and subjected to a suitable mechanical process, the clay falls into fine dust, while the coal particles, on the contrary, retain their granular nature. The method is carried out by drying the mud and a subsequent fine shifting, which affects a breaking up of the lumps that occur in the dried "schlamm," and a separation into the two products above named. The dust that falls through the sieve has a high ash content, being in the nature of flour, while what remains behind is granular and has a low ash content.

MISCELLANEOUS NOTES.

About 10,000 pounds of eiderdown are collected annually in Iceland, 7,000 being exported to foreign countries. Formerly the peasants used to receive about $5 a pound for it, but the price has now fallen to half that amount.

The Librarian of Congress reports that the copyright entries for the year 1897 were classified as follows: Books, the drama, periodicals, music, maps, charts, engravings, prints, chromos and lithographs, photographs and miscellaneous matter. The total number of entries made during the year was 103,875, and of that number 1,963 entries were those of photographs accompanying works of art. Under the heading of "Fine Arts," there were the following sub-divisions: Paintings, of which there were 790 entries; drawings, with a total 1,144 entries; and 29 entries of photographs of statuary.—Architecture and Building.

Several years ago, when the supply of natural gas showed such a decided drop, it was predicted that the new fuel would before long be a thing of the past. The latest report of the Philadelphia company, which has been the most extensive operator in natural gas, indicates that the supply is holding out unexpectedly well, says The American Manufacturer. This report is the thirteenth annual statement made by this company, and shows that during the past year it drilled 51 wells, 31 being productive of gas, 11 of oil, and 10 dry. The company is now operating 924·41 miles of pipe, has 68 telephone stations, and 380·3 miles of telephone wire. The amount of natural gas sold during the past year was 10,857,956,000 cubic feet, all of which was sold by meter.

Synthetically prepared indigotine, according to O. N. Witt (Chem. Ind., xx., 454), has passed the experimental stage, and is now likely to become a successful rival of natural indigo. It can be produced at a price comparable with good quality indigo and cheaper than refined indigo. There are several points in its favor, such as purity of product, fineness of division, and in its being readily tested; while the synthetic indigotine dyes wool equally as well as natural indigo, the former, through lack of impurity, does not answer so favorably with cotton until the cotton fiber has been impregnated with certain substances acting as mordants, such as Turkey red oil, glue, albuminoids, etc., but cotton so treated and dyed has a fine purple shade. For the manufacture of indigo extract and indigo carmine, synthetic indigotine is now exclusively used by one firm of manufacturers in preference to refined natural indigo.—Journ. Chem. Ind., xvii., 41.

The Union Médicale for July 18 contains an abstract of a review of a report made by M. Volintzeff to the Surgical Society of Moscow, which was published in the Gazette des Hôpitaux. The results of the author's investigations are summed up as follows: The density of this product is much greater than that of cotton or of tarlatan; it is less porous than either of them and less hygroscopic. The escape of vapors takes place more slowly under a dressing of asbestos than under all others. It is not as good a conductor of heat as cotton, but on this point, says the writer, the results of the investigation are not yet perfectly satisfactory. Asbestos absorbs the albuminoid solutions better than absorbent cotton or tarlatan does. In regard to the clinical observations, says the writer, M. Volintzeff thinks they are yet too small in number to enable him to give a definitive judgment. The product is not expensive, because it may be used several times.—New York Medical Journal.

There are 20,000 newspapers in the United States, of which 2,250, or more than ten per cent., are published daily. These daily papers, however, are not distributed uniformly throughout the several States, and there seems to be no clear rule for the discrepancies to be found in some States. New York, for instance, the largest of the States in respect to population, and the one, too, having the largest number of newspapers, has only 183 dailies, whereas Pennsylvania, the population of which is 1,250,000 less than New York's, has 201. Missouri, with a population of 2,600,000, has only 87 daily papers, while Indiana, with a population of 500,000 less, has 137, yet the Hoosier State, with Illinois on one side and Ohio on the other, has not usually been noted for its public enlightenment. On the other hand, Missouri has 709 weekly papers, whereas Indiana has 577. The population of Massachusetts by the last census taken—the State census of 1895—was 2,500,000. The population of California at the same time was 1,250,000, or just one-half. Massachusetts has long had a high rank in all matters connected with education and public enlightenment. It is the State of several universities, it is prominent in all educational matters, and it is one of the very oldest of the States of the country in point of settlement. Yet Massachusetts has only 88 daily papers, whereas California, with one-half the population of the Bay State, has 113. These are some of the discrepancies which seem to require explanation. The distribution of daily papers throughout the country is in other respects singular. Mississippi, with a population of 1,250,000 and with large mercantile and agricultural interests, has only 9 daily papers, whereas Arizona, with a population one-twelfth as large, and much of it made up of persons wholly illiterate or nearly so, has 10 daily papers. Delaware, including the thriving city of Wilmington, and with no foreign population numerous enough to be considered, has the same number of daily papers as New Mexico with a population of 25,000 less, and a considerable portion of Indians and half breeds. There are only 19 daily papers in the State of Tennessee, only 15 in West Virginia and 29 in Kentucky. But in North Carolina, a State destitute of large cities, there are 21 daily papers, and in Arkansas there are 26. New Hampshire and Vermont are neighboring States; their population is about the same—between 350,000 and 375,000. Yet New Hampshire has 15 daily papers and Vermont has only 4. Connecticut has, relatively, more daily papers than has Massachusetts. Iowa has more than Texas, and Idaho has fewer than any other State or Territory with the exception of Alaska, though this condition may not be permanent when the belated returns have been received from the Klondike, where heretofore journalism has not flourished. The United States have more daily papers than any other country, but their distribution is peculiar.—New York Sun.

SELECTED FORMULÆ.

To Prevent Nickeled Objects from Becoming Dim.—To clean nickel plated objects dip them for a second or two in a two per cent. solution of sulphuric acid, rinse in running water, and finally with a mixture in equal parts of distilled water and alcohol. Dry in sawdust.

To Remove Spots from Varnished Furniture.—Make a mixture in equal parts of linseed oil, alcohol and oil of turpentine, and with this mixture moisten a flannel rag. Rub the spots well, and in a few moments they will vanish, then polish off with a bit of soft blotting paper.

Medium for Mounting Pollen and Starch.—The following formula was originally devised by Charles Bulloch:

Acacia, selected	4 drachms.
Glycerine	3 "
Distilled water	3 "
Thymol, about 1 gr. to every 3 or 4 oz.	

Place the ingredients in a wide mouthed bottle, cork carefully to exclude dust and put in a warm place to remain until solution is effected. The latter may be hastened by occasional stirring from the bottom with a bone spatula. When finally you have secured complete solution, strain off the liquid through double folds of a silk handkerchief, or through fine linen. Under ordinary circumstances (at the temperature of the room) this will require a week, but the process can be accelerated by the application of a gentle heat. All of the work is rendered unnecessary if one has a jacketed filtering apparatus. Absorbent cotton in the delivery tube of the funnel will clear the liquid of all insoluble matter, dirt, etc., and of air. For cells use zinc-white cement.—Popular Science News.

Colorless Developer.—For some purposes it may be of importance to have a developer which will keep absolutely colorless. This is particularly of advantage with chloro-bromide of silver plates, which accept color very easily from the developer. The following formula is therefore recommended in The Photographic Bulletin:

I. Hydroquinone	5	grammes.
Metabisulphite of potassium	5	"
Bromide of potassium	0·3	"
Water	600	cu. cm.
II. Caustic soda	13	grammes.
Water	600	cu. cm.

Mix 60 cubic centimeters I. with 30 cubic centimeters II. This developer will remain colorless for days.

Black Lead for Pencils.—A correspondent of The Pharmaceutical Era has tried without success the following formula: Ten parts by weight of plumbago, seven parts German pipe clay, made into a stiff paste and run through a mould, and then bake in an oven (such as is used in baking emery wheels). The editor of that journal says: The successful production of pencil leads is a very valuable trade secret to the manufacturers of pencils, and we cannot be confident of giving you any very satisfactory information on this subject. However, in a general way it may be said that black lead for pencils is usually prepared by one or another of the following methods:

(1) The blocks of plumbago are exposed to a bright red heat in a closely covered crucible, and are afterward sawed into minute sticks and mounted in cases of cedar or satin wood.

(2) The plumbago, in powder, is calcined as before and then mixed with an equal or any other desired proportion of pure washed clay, also in powder, after which the mixture is reduced to a plastic state with water and pressed into grooves cut on the face of a smooth board or into well greased wooden moulds, in which state it is left to dry. When dry the pieces are tempered to any degree of hardness by exposing them, surrounded by sand or powdered charcoal, to various degrees of heat. The crucible is not opened until the whole has become cold, when the prepared "slips" are removed and mounted as before. This method was invented by M. Conte in 1795.

(3) The dough or paste prepared as last is reduced to the required form by forcing it through a perforated plate (in a similar manner to that adopted for colored crayons) or into minute metallic cylinders from which it may be readily shaken after it becomes partially dry. The leads for some varieties of drawing pencils are immersed for a minute in very hot melted wax or suet before mounting them. To the composition for others a little lampblack is added to increase and vary the degree of blackness.

How to Preserve Yeast in Full Activity for a Year.—The preservation of yeast in its full activity for any great length of time has long been a problem at which many have labored, but the inherent difficulties have, up to the present, been such that most experimenters gave the question up as insoluble. None of the antiseptics could be used, because in destroying the germs of fermentation the life of the yeast itself is destroyed. An experimenter in Germany, remembering the extraordinary tenacity of life exhibited by a great many species of micro-organisms, and even by many animalcules far higher in the scale of life, under drying, concluded to try desiccation, carried to the limit on the yeast cells, and was gratified to find that yeast thus dried can be kept for at least a year (how much longer is not stated, because only this length of time has elapsed since his experiment was undertaken) without losing any of its vitality. The process consists in making up the yeast cake into pellets the size of a pea, which are left to dry spontaneously. After a few hours, potato starch, which has been carefully dried in an oven at a low temperature (to avoid conversion into dextrin), is sifted over the pellets in considerable quantities, and the whole is put into a drying apparatus, consisting of a sheet iron cylinder so mounted that it rotates at a certain distance over gas jets (or other source of heat), so that the temperature can be maintained sufficiently low to prevent injury to the life of the yeast—the lower, the better. In this the yeast pellets and starch are kept rotating for several hours, or until all moisture is expelled. The whole is then thrown in a sieve, and the starch recovered for further employment, and the yeast pellets are then ready for putting up in airtight containers.—National Druggist.

SIR HENRY BESSEMER.

THE life of the late Sir Henry Bessemer, who died March 14, is so interesting and important that we give an extended biography of him, abridged from W. T. Jeans' "The Creators of the Age of Steel."

Henry Bessemer was born at Charlton, in Hertfordshire, in 1813. His boyhood was spent in his native village, while he received the rudiments of an ordinary education in a neighboring town. His early years were devoted to the cultivation of his inventive faculties. His father sent up to London and purchased a five-inch foot lathe for his son's use. The latter was much interested in eccentric turning and engraving on steel, and at the age of eighteen he came to London, where he worked as a modeler, designer and engraver. He worked with so much success that at the age of nineteen he exhibited one of his models at the Royal Academy. He then gave his attention to some plans for the protection of stamps for deeds, etc. The government lost large sums by the surreptitious use of old stamps instead of new ones, and young Bessemer devised a die which perforated the parchment with some 6,400 holes; these holes formed the stamp. Henry Bessemer was rewarded by the offer of the position of superintendent of stamps, with a salary of $3,000 per annum. As he was engaged to be married at the time, he gladly accepted, but the young lady to whom he was engaged suggested that if all the stamps had a date put on them, they could not be used fraudulently. It was not without regret that he saw the results of the many months of experiment superseded. He had such confidence in the government that he boldly placed the matter before Sir Charles Persley. The new design was preferred and the first invention of Bessemer was abandoned, and the Stamp Office reaped the benefit, while young Bessemer did not receive a farthing. He was very shabbily treated by the government, and he often said, "I had no patent to fall back upon."

He then invented a machine for obtaining good patterns of the figured Utrecht velvet. The next matter that seriously engaged his attention was the process of type casting, the improvements in which formed the subject of his first patent. His attention was then accidentally turned to the manufacture of bronze powder. He worked a year and a half at the problem of producing a cheap bronze powder and finally succeeded in making a superior article which cost only one dollar a pound, which was superior to the article then sold at $28 a pound. He at once sent out a traveler with samples of it, and the first order he got was at $20 a pound. A friend put $50,000 in the business, and Bessemer to insure secrecy made plans of all the machinery required and then divided them into sections. These were sent to various engineering works, and he assembled and fitted the pieces himself. He then engaged four or five men and paid them very high salaries on condition they kept everything strictly secret. To this day the method by which this famous gold paint is produced remains a secret. The machinery is driven by an engineer in an adjoining room to the laboratory where the automatic machinery is at work. None but the inventor and his assistants have penetrated into this room. The machinery has been in constant use for over forty years without having been patented or pirated, so that strange to say we have among us a manufacture wholly unimproved for thirty years. Sir Henry rewarded the faithfulness of two of his assistants who survived the five original helpers by handing over to them the business and the factory.

Other matters that engaged his attention between 1844 and 1854 were the manufacture of paints, oils and varnishes, the manufacture of sugar, the construction of railway carriages, centrifugal pumps, projectiles and ordnance. Up to 1847 the luggage of passengers was carried on the roofs of the railway carriages. Bessemer demonstrated that this was a senseless custom, owing to the resistance of the air, and the practice was subsequently abandoned. He also turned his attention to the causes of explosions in coal mines, and in the exhibition of 1851 he exhibited four different kinds of machines. In 1853, when the public mind was much exercised by the prospects of impending war with Russia, he devoted his efforts to the improvement of projectiles and ordnance then in use. He constructed elongated projectiles to which a rotary motion was imparted during their passage through the air without the aid of rifled grooves. His plans were laughed at by the government authorities at Woolwich Arsenal, and at a dinner in Paris he met the Prince Napoleon, to whom he took occasion to mention his plan of firing elongated projectiles. So favorably was the prince impressed by the invention that he asked Bessemer to explain it to the emperor, and with this object in view arranged an interview. The emperor gave him facilities for continuing his experiments at Vincennes and advanced him money for this purpose. The results were considered very promising by the French authorities, and at this moment, when success seemed to be on the point of crowning his labors, an incident occurred that changed the whole course of his future life and materially affected the industrial progress of the world.

When Bessemer had shown to the French military authorities at Vincennes the results of his system of firing elongated projectiles from a light cast iron smooth bore gun, Commander Minie, who superintended the trials, remarked to him: "The shots rotate properly, but if you cannot get stronger metal for your guns, such heavy projectiles will be of little use." It was this observation that led Sir Henry to think of improving the manufacture of iron. In reporting the results of his artillery experiments to the Emperor Napoleon, he intimated his intention of extending his researches to the kinds of metal most suitable for artillery purposes. His Majesty gave him every encouragement and requested that the results might oe communicated to him. Bessemer then returned to London.

He did not in the least know how he was going to effect improvements, for both the history and the rudiments of practical metallurgy were unknown to him; but he studied all the books available and visited large industrial establishments. He arranged for the use of an old factory in St. Pancras, London, where he began his series of experiments. He converted the factory into a small experimental iron works, in which his first object was to improve the quality of iron. For this purpose, he made costly experiments, without the desired measure of success; but, after twelve months spent in constant experimentation, he produced an improved quality of cast iron, which was almost as white as steel, and was tougher and stronger than the best cast iron then used for ordnance. Of this metal he cast a small model gun, which was turned and bored. This gun he presented personally to the emperor. His Majesty encouraged him to continue his experiments. As Sir Henry continued his labors, he extended their scope from the production of the refined iron to that of steel, and, in order to protect himself, he took out patents for each successive improvement. One furnace after another was pulled down and numerous mechanical appliances were designed and tried. At the end of eighteen months, he says, "the idea struck me" of rendering cast iron malleable by the introduction of atmospheric air into the fluid metal. The first experiment to test this idea was made in a crucible, in the laboratory. He then found that, by blowing air into the molten metal in the crucible, by means of a blowpipe, he could convert ten pounds of crude iron into the softest malleable iron. The samples thus produced were so satisfactory that he brought them under the notice of the superintendent of the royal gun factories, who offered him facilities for experimenting in Woolwich Arsenal. Prof. Abel made numerous analyses of the material as he progressed with his experiments. The first piece of metal that was rolled at Woolwich was preserved by Sir Henry as a memento.

In order to produce larger quantities of the metal in the way he devised, one of his first ideas was to apply the air to the molten iron in crucibles, and, accordingly, in October, 1855, he took out a patent embodying this idea. This device is illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 1092. He then proposed to erect a large circular furnace, with openings for the reception of the melting pots containing fluid iron and pipes for conducting air into the center of each pot. This is also illustrated in SUPPLEMENT, No. 1092. His chief difficulty was in knowing how to force the air all through the mass of liquid metal.

He was attacked by a severe illness about this time, and while lying in bed he worked out a scheme which was the germ of the Bessemer converter. On recovering, he constructed a circular vessel, measuring 3 feet in diameter and 5 feet in height, and capable of holding 700 pounds of iron; and he next ordered a small, powerful air engine and a quantity of crude iron to be put down on the premises in St. Pancras, which was formerly the residence of Richard Baxter, and the simple experiment we are now going to describe has made that house famous.

The primitive apparatus being ready, the engine was made to force streams of air, under high pressure, through the bottom of the vessel, which was lined with fire clay, and the stoker was told to pour the metal, when it was sufficiently melted, in at the top of it. A cast iron plate—one of those lids which commonly cover the coal holes in the pavement—was hung over the converter; and all being got ready, the stoker, in some bewilderment, poured in the metal. Instantly out came a volcanic eruption of such dazzling coruscations as they had never seen before. The dangling pot lid dissolved in the gleaming volume of flame, and the chain by which it hung grew red and then white, as the various stages of the process were unfolded to the gaze of the wondering spectators. The air cock, to regulate the blast, was beside the converting vessel, and no one dared to go near it, much less to deliberately shut it. In this dilemma, however, they were soon relieved by finding that the process of decarburization or combustion had expended all its fury; and, most wonderful of all, the result was steel! The new metal was tried. Its quality was good. The problem was solved. The new process appeared successful. The inventor was elated.

Astonished at his success, he went to the Patent Office and examined all the patents, but could find no trace of a similar process. Sir George Rennie was asked to inspect the works, and was so much delighted with the process that he invited him to read a paper before a section of the British Association. On reaching Cheltenham, Bessemer was introduced to Mr. Nasmyth, who, when shown the specimens of metal, said, "That is a real British nugget." Bessemer read his paper, which was enthusiastically received by the metallurgists present. The first public announcement of the Bessemer process was made at Cheltenham, August 11, 1856. Baxter House then became a place of pilgrimage and many inquirers were anxious to see the wonderful invention in operation. The Emperor Napoleon had intimated his intention of bringing it into practical operation at the Arsenal at Roulle. Experiments were tried elsewhere with very indifferent results. Some experiments proved to be total failures, but at last numerous overtures were made to the successful inventor for permission to work the process in England; £50,000 was offered for the patent, which was refused.

Bessemer divided Great Britain into five principal iron districts, and announced he wanted one iron master in each district to have so great an interest in the successful results of the invention that he would always act for him instead of against him. He proposed that any iron master who was the first to apply for his district for a license should try the process, paying the one year's royalty, but no other royalty during the fourteen years of the patent, so that he should be interested very strongly in maintaining the patent, in improving it and making the nucleus of the operation in his district. Three weeks after the reading of his paper, licenses amounting to $125,000 were taken out. The Dowlais Iron Company was the first to make a practical test. The result of the experiment was a failure, and exactly six weeks after the first description of the process appeared in The London Times a meeting of iron masters condemned the new process as practically a failure.

Bessemer, aided by the additional capital he had obtained through the sale of the licenses, quietly set to work to investigate the problem. The analyses made by Prof. Abel for Bessemer showed that the real cause of failure was the excess of phosphorus. He now conducted a series of costly experiments. He obtained some pig iron from Sweden which was free from phosphorus. When this was put in the converter it yielded in the very first experiment a metal of so high a quality that he at once abandoned his efforts to dephosphorize ordinary iron. The analysis of the metal which he obtained showed that it contained 99·84 per cent. of pure iron. He had now succeeded in making the purest malleable iron by a quick and comparatively inexpensive process, but what he wanted was to make steel. The former is iron in its greatest possible purity. The latter is pure iron containing a small percentage of carbon to harden it. Sir Henry discovered that by introducing a small quantity of ferro-manganese into the converter, sufficient carbon was imparted to the iron to give it the properties of steel of a high quality. Mr. Robert Mushet proclaimed that he was the first to apply manganese to Bessemer steel, and though Sir Henry was never proved to have infringed any patent right through the use of manganese, Sir Henry generously allowed the disappointed chemist an annuity of $1,500 per annum.

Bessemer now discovered the necessity of manufacturing ferro-manganese on a large scale for his process, because it would enable him to make a very mild steel and because the use of spiegeleisen would not do so, owing to the large quantity of carbon in it, and there were other problems which he was required to solve. The intense heat necessary and the great affinity of manganese oxide for bricks was so great that for a long time the problem baffled him. He tried one refractory substance after another and at last took some coke and ground it fine. This was mixed with enough tar to cement the particles together, and having put it in an iron mould he heated it to a red heat; he thus obtained fine solid carbon bricks. These were built into a furnace with which he had henceforth no difficulty. There was now little difficulty in getting an adequate supply of ferro-manganese. In the meantime the converter was also improved. He had the converter holding the molten iron mounted on an axis, which enabled him at any moment to turn it around and bring the air holes in the bottom above the level of the metal. Whenever this was done, the process of conversion or compression ceased of itself, and the apparatus had only to be turned back again in order to resume the operation. This turning on an axis of a furnace weighing eleven tons and containing five tons of liquid metal at a high temperature was a system entirely different from anything that ever preceded it. He took out important patents concerning this furnace. The patent for the turning of the converter was taken out about four years after his original patent for the converter. The Bessemer process was now perfect. It only remained to bring it into general use, and this was the work which next engaged his attention.

His first task was to convince the public that an invention which for two or three years had been attempted was now a success. To do this required the exercise of more than ordinary skill and courage. After converting hematite iron, henceforth to be called Bessemer iron, into steel by his process, he wished to demonstrate its properties by actual use. He gave a quantity of the steel to Mr. Galloway to distribute among his workmen. They found there was no difference in this and other steel, but the steel which they had formerly used cost $300 per ton, while the new steel cost less than $40.

Bessemer now brought the merits of his process before the attention of the Institution of Civil Engineers, explaining in detail the difficulties which he had surmounted since the discovery of his process. He exhibited specimens and explained the severe tests which they had stood. Notwithstanding numerous proofs of this sort, some of the speakers who addressed the meeting after hearing the paper read, expressed grave doubts as to the practical working of the process. On the whole, however, the paper produced such a favorable impression as to the ingenuity of the process that the institution resolved to present to the author the Telford gold medal. Bessemer and his partner joined with the Messrs. Galloway for the purpose of erecting works for the production of the new steel. Land was bought at Sheffield and works were erected thereon by them with the determination of convincing the people that the process was really good, or else, failing in the attempt, to give the thing up. He then swept the market clear of all the licenses, buying them back, and in due time the works were erected and the product was sold. The beginning was a small one, but at last the manufacturers in Sheffield began to say, "Why, these people are underselling us by twenty pounds a ton." Then the new process began to make progress. The superiority in respect of rapidity and cheapness over the old process soon spread consternation in the steel trade. One manufacturer after another applied for a license to use it, and it may truly be said at this period that the age of steel began to succeed iron as iron superseded the bronze age. The new material began to be used for everything. Girders, bridges, marine engines, shafts, screw propellers, anchors and railway rails, wheels, etc., were all made from the new product.

The inventor was now reaping handsome profits from his invention and its success was practically established, but its usefulness was not generally appreciated. The application of the new steel for industrial purposes had yet to be accomplished, and Sir Henry found that this was not the least formidable part of the work before him. At the Great Exhibition of 1862, he exhibited numerous specimens of his steel manufactured in a variety of articles ranging from steel ordnance to steel wire of $\frac{1}{12}$ of an inch in diameter. Specimens made by the same process were also shown, that had been sent by companies in India, Sweden, France, Germany and Austria, where Bessemer steel was then being produced. The history of the process was as eventful abroad as at home, and speculators negotiated the purchase of patent rights for Spain, the least industrial country of all Europe. Sweden was the first country to adopt the Bessemer process, which it did soon after the first announcement of its success. The exceptional purity of the iron made in that country made it especially suitable for the converter. The first Bessemer steel ingot ever rolled in England came from Sweden. It was rolled into a circular saw plate five feet in diameter and was preserved by Bessemer as the first steel article produced by precisely the same apparatus and the same method of treatment that he described at Cheltenham in 1856. In Germany the greatest steel maker was Krupp of Essen. Before Bessemer had taken the preliminary steps to obtain a patent there, Krupp entered into negotiations with him and agreed to pay $25,000 for the use of his invention. The unsuspecting inventor sent all his papers to Krupp, who in due course applied to the Prussian government for a patent. This was denied, so that this concern was not allowed to

profit by their sharp practice. The process was worked in Germany without the payment of any royalty to the inventor. There was a similar result in Belgium. The process was also promptly appropriated in France, the Messrs. Schneider, of Creusot, being the sinners in this case. While the inventor saw one foreign steel manufacturer after another adopting his process, eluding the payment of his royalty, he had the satisfaction of seeing its steady progress in England, as well as on the Continent and in the United States. Bessemer had to contend with British prejudice; even the authorities of Woolwich Arsenal declining to use it for ordnance. It will be remembered that the need of a stronger metal for ordnance was the reason for Bessemer giving serious attention to metallurgy. In 1882 the British government determined that the manufacture of wrought iron guns should be discontinued and that all guns in future should be made of steel. In 1861 Bessemer proposed to the engineers of the London and Northwestern Railway to try the use of steel instead of iron rails. The first order of the material was for ten tons. The metal was severely tested and rolled into rails. These rails were exhibited at the Great Exhibition in 1862, and they were afterward put down at Crewe on the day the Prince of Wales was married. Speaking of these same rails in 1881, Mr. Webb, chief of the locomotive and rail works of the London and Northwestern Railway Company, stated that they had remained there ever since with the exception of ten months, when he borrowed them to send to South Kensington, and the bulk of the "up" traffic through Crewe station passed over them. Formerly they had to change the iron rails every nine months. At the very mention of the steel rails Mr. Ramsbottom, the engineer, said, "Mr. Bessemer, do you wish to see me tried for manslaughter?"

At the Birmingham meeting of the British Association in 1865, Bessemer explained that at Chalk Farm steel rails were laid on one side of the line and iron rails on the other, so that every engine and carriage had to pass over both steel and iron rails at the same time. When the first face was worn off an iron rail, it was turned the other side upward, and when the second face was worn out, it was replaced by a new iron rail. When Sir Henry examined one of the steel rails, only one face of it was nearly worn out, while on the opposite side of the line eleven iron rails had at the same time been worn out on both faces. It thus appeared that one rail of steel was capable of doing the work of twenty-three iron rails. In 1863 Mr. Ramsbottom had the first locomotive boiler made of Bessemer steel plates. This locomotive boiler lasted until 1879, a much longer time than the average life of an iron boiler.

Next to rails, shipbuilding is the industry which is the largest consumer of iron. In 1862-63 Bessemer brought the attention of shipbuilders to the superiority of his metal over the iron used in ships. In 1863 a stern-wheel barge was built out of Bessemer steel. Its use then became very general, as it was found that many serious wrecks were prevented by its use. In 1864 there appeared in the Times an account of some experiments made with the Bessemer steel, with spherical shots fired from a smooth-bore gun against a 5½-inch armor plate, and Sir Henry remarked that "their destructive effects as compared with projectiles made of cast iron entirely confirmed the views which he had so long advocated in vain."

The British government did not adopt the steel projectiles for many years after. Bessemer said, "It is remarkable that while our firm had manufactured at Sheffield some 150 pieces of Bessemer steel ordnance for foreign service, guns made of this material are still untried by our government, although it is well known that the strength of this metal is double that of ordinary iron." Bessemer [illegible] his steel projectile, said, "Have we [illegible] ship afloat that can keep out these simple round steel shots fired from a common smooth-bore gun if ever directed against us? This is a grave question and demands a speedy answer." The practical answer to this question was given by the British government twelve years later.

It need scarcely be said that Sir Henry Bessemer was a believer in patents; but to his varied experience in the introduction of new inventions, another singular fact has to be added. "I do not know," he said, "a single instance of an invention having been published and given freely to the world, and being taken up by any manufacturer at all. I have myself proposed to manufacturers many things which I was convinced were of use, but did not feel disposed to manufacture or even to patent. I do not know of one instance in which my suggestions have been tried; but had I patented and spent a sum over a certain invention, and saw no means of recouping myself except by forcing, as it were, some manufacturer to take it up, I should have gone from one to the other and represented its advantages, and I should have found some one who would have taken it up on the offer of some advantage from me, and who would have seen his capital recouped, by the fact that no other manufacturer could have it quite on the same terms for the next year or two. Then the invention becomes at once introduced, and the public admits its value; and other manufacturers, like a flock of sheep, come in. The first man might say: 'Oh, my machinery cost me a great deal of money. I have my regular trade, and this new scheme is sure to be more trouble to me in the first instance; and when everybody asks for it, every other manufacturer will be in a condition to supply it, so it is not worth my while.' I believe inventions which are at first free gifts are apt to come to nothing."

Sir Henry took out 120 patents for inventions, and it is calculated that he has paid to the Patent Office of Great Britain $50,000. Specifications for these patents filled two bulky volumes, and the drawings illustrating them, every one of which was executed by himself, filled seven large volumes. He was now in receipt of a princely income and devoted his attention to the solution of other problems. He devised a process for fusing metals in a furnace in which air was forced at a pressure of twenty pounds to the square inch. By this means all the heated gaseous products of combustion were compressed into half the space occupied by an ordinary furnace, and there was a corresponding increase of temperature. In 1871 Sir Henry was selected to succeed the Duke of Devonshire as president of the Iron and Steel Institute. In 1869 he constructed a saloon for passenger vessels in which the vibrating motion which is supposed to cause sickness should be prevented or minimized. The model was erected on his estate at Denmark Hill, and it was found to realize his expectations. A company was soon formed and Sir E. J. Reed designed a vessel, 350 feet long, especially adapted for the reception of a swinging saloon, 60 feet long, 30 feet wide and 10 feet high. The vessel was launched on September 24, 1874, and was named the "Bessemer." The vessel was not successful. He next occupied himself with the construction of a novel telescope, on which he spent $100,000. In 1875 he designed a lathe capable of giving to large pieces of rough or plain glass the general form or curvature required for telescopes and other optical instruments and reflectors. In brief, it consisted of a face plate and an apparatus which guides a tool with a diamond set in it. The telescope which Sir Henry constructed stands on the Bessemer estate at Denmark Hill. In literature Sir Henry has done very little except to write an occasional paper explaining his own inventions.

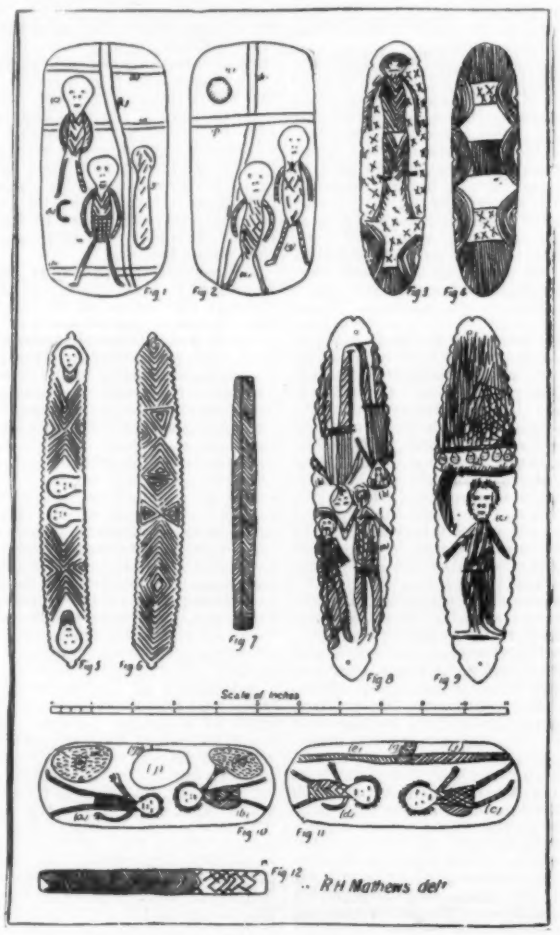
It is almost needless to say that Sir Henry received many honors. He was presented with the freedom of the city of Hamburg; the King of Würtemberg presented him with a gold medal; the Emperor of Austria conferred an order upon him; Emperor Napoleon III. conferred the Grand Cross of the Legion of Honor upon him, but the English government refused permission to him to accept it; but on the occasion of the next Paris Exposition, the emperor presented him personally with a magnificent gold medal. Other medals were given him, and several cities were named in his honor. It would seem from what has already been said that the British government always treated Sir Henry slightingly, but this was not always the case. In 1872 the Albert gold medal was presented to him by the Prince of Wales. This was the first national recognition of his services. In 1879 the honor of knighthood was conferred on him by the Queen, and in 1880 the freedom of the City of London was presented to him.

THE POSTAL SERVICE OF AUSTRALIAN ABORIGINES.

Mr. R. H. Mathews, who has exceptional opportunities of studying the customs of the aborigines of Australia, has lately described a number of message sticks or stick letters, used as a means of conveying information from one tribe to another. These sticks, a few of which are shown in the accompanying reproduction of Mr. Mathews' drawing in The American Anthropologist, are highly interesting, as illustrating an attempt by a primitive and uncultivated people to develop some method of communicating their thoughts to persons at another place by means of symbols.

It would take up too much space to describe in detail the significations of the various markings upon the talking sticks here illustrated; the general meaning of a few may, however, be pointed out. The two sides of the stick represented in Nos. 1 and 2 contain a message from Nanee, a head man of one tribe, to Belay, one of the head men of another tribe, appointing a meeting for the purpose of holding a corroboree. Nanee (a) sent the message from the river (b) by the messenger (c), via the rivers (d), (e) and (f), to Belay (g); the stick was dispatched at new moon (h), and Belay and his tribe are expected to be at the river (f) at full moon (i). The ground where the two tribes are to hold a big corroboree is indicated by (j). The messenger is shown standing by Belay, the receiver of the message, to indicate that he will remain with the latter and his tribe until they are ready to start for the place of meeting. Nos. 5 and 6 represent a stick used to convey a similar message from two brothers (represented by the two heads in the middle of the stick) of one tribe to two brothers of another tribe. Nos. 8 and 9 signify that a head man (a) with his wife (represented by the figure alongside) and two other blacks (b), wish to meet the recipient (c) of the message, and desire that he will bring the blacks of his own tribe with him. Nos. 10 and 11 request that the recipient of the message stick will muster his tribe for a big corroboree, and show the tracks to be followed to the ground where the meeting will take place.

Mr. Mathews is of the opinion that, generally speaking, these stick letters are only supplementary to verbal messages, the pictures and marks upon them serving to assist the memory of the messenger and also to confirm the genuineness of the messages. The bearer of a message stick is never molested, even when he has to pass through the districts of tribes unfriendly to his own.



AUSTRALIAN MESSAGE STICKS.

ELECTRIC CASTING.

Since the introduction of the electric welding process, now well known, there has been introduced the Slavianoff electric casting process, in which the heat produced by the electric arc is utilized, the process consisting chiefly in pouring a metal, which has been melted by means of an electric current, on the surface of any metallic body, portions of which also become molten, and so intermix with that poured on as to form practically one piece.

In this process of the two metallic electrodes, one serves as the material for the casting, and is generally in the form of a bar, the other electrode differing widely, according to circumstances. As the bar of metal melts away under the action of the arc, the molten metal drops into a receptacle which forms the second pole, and is not allowed to cool immediately, but is kept in the molten state by keeping the arc playing on the surface. Further, the fact that twice as much heat is developed at the positive pole as at the negative is also taken advantage of to concentrate the heat on the material to be cast, and it is found that with cast iron the quality of the casting is somewhat affected by the sign of the pole. To get over the difficulty of feeding, Mr. Slavianoff has devised a very ingenious automatic regulator, which is fully described and illustrated in a paper by A. Lohmann (Elektrotechnische Zeitschrift, 1895, No. 22), which regulates the hand feeding of the workman in such a way as to wipe out all small irregularities. The strength of the current employed is from 7·5 to 8 amperes per square millimeter of sectional area of the bar to be melted, with a constant voltage of from 50 to 75 volts. With the Slavianoff regulator any ordinary dynamo may be employed, although care must be taken that the sudden variation of load, due to putting on say 500 amperes, will not unduly strain the machine.

In the paper referred to above, the author, after pointing out that the method is naturally more expensive than that ordinarily adopted (but the cases in which it finds application are of such a nature that cost is not of first importance), proceeds to detail various applications of the process, some of which are given below:

1. Small articles can be cast in the following manner: In a graphite crucible a rod of the material to be cast is placed in such a position that the arc takes

place just on the bottom of the crucible. The other pole being worked vertically by means of the regulator, then, as the metal melts, the vertical rod is drawn up, thus keeping the arc playing on the surface, while the other rod lies in the molten metal, and gradually melts away. By using rods of different metals it will be seen that we can produce any desired alloy in this way.

2. Broken pieces of machinery can be melted together again.

3. Cracks in any metal object can be repaired.

4. Worn surfaces can be repaired by melting on a new piece and resurfacing.

5. Porosities of all kinds in castings of iron, steel, copper or the bronzes can be filled up successfully without difficulty.

6. Different metals may be melted together into one piece, as, for instance, cast iron to steel, copper or bronze to cast iron, etc.; also a layer of hard cast iron can be superposed on a piece of softer quality, which would be useful in many cases, as, for example, the valve faces of steam and other engine cylinders.

7. Holes which have been drilled by error in incorrect positions, or which, by reason of alteration of design, are no longer required, may be readily filled up.

The author then discusses a number of instances of repairs that have been effected by means of this process, which may be well illustrated by the case of a fly-wheel 7 ft. in diameter and of 2,000 pounds weight. The wheel had been working several years, when, to suit an alteration in the engine, it became necessary to drill it out to receive a larger shaft, when in handling it was accidentally dropped, and its rim broken. No pattern being to hand and delivery urgent, it was repaired by the insertion of a new piece in the broken portion by means of the electric casting process, at a total cost of about 15s., and has been running ever since.

In conclusion, a special feature of the process—the change of the hard white quality into soft gray cast iron—may be mentioned.—The Practical Engineer.

PHOTOGRAPHIC INVESTIGATION OF A 150,000 VOLT POWER DISCHARGE.

By CHARLES PROTEUS STEINMETZ.*

To investigate the phenomena taking place during a disruptive discharge at very high voltage and in a circuit of sufficient power to maintain an arc, a series of photographs were taken, differing from each other by the length of exposure.

As discharge terminals there were used two one-half inch brass spheres, separated from each other by 14 inches, and in some cases by 15 inches. The camera was focused on the discharge terminals, the generator field excited to give 150,000 volts effective at the discharge terminals, then the cap was taken off the lens, the generator switch closed, and thereby the disruptive discharge started, and the generator field switch opened after the discharge had lasted the desired time.

The generator was a smooth core 125-cycle single phaser, giving a wave very closely resembling a sine wave. The ratio of maximum to effective value of the generator wave is 1·42. The generator, G (see diagram) feeds four 7·5-kw. type F transformers, F', stepping down by the ratio of 10 to 1. These transformers feed again four 7·5-kw. type F transformers, F'', stepping up by the ratio of 1 to 20, and these latter transformers feed four special oil transformers, H_1 H_2 H_3 H_4, of the ratio 1 to 18. These were connected in series with their high potential sides to the electrodes, thus giving a total ratio of 1 to 144.

The voltage was measured by a Weston voltmeter, V, in the low tension circuit. An extended series of preliminary investigations had shown that the high potential voltage can by these means be determined accurately within less than one per cent., irrespective of the capacity of the discharge circuit within certain limits.

The total impedance of the system, inclusive of the impedance of the generator, is reduced to the high potential discharge circuit:

$$Z = (80-390\,j)\,10^3 \text{ ohms, or absolute,}$$
$$z = 398 \times 10^3 \text{ ohms.}$$

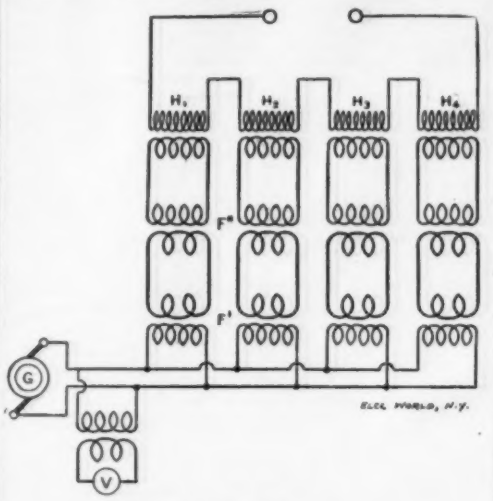


DIAGRAM OF TRANSFORMER.

The generator excitation corresponded to a potential in the discharge circuit of 184,000 volts effective.

Thus, while before the discharge the voltage at the electrodes was 150,000 effective, at short circuit between the electrodes the current is 0·465 ampere effective, and the maximum output available in the discharge circuit between the electrodes is 35·5 kilowatts.

The photographs differ according to the length of exposure.

Photograph Fig. 1 was taken with small opening of the lens and 15 inches striking distance; Fig. 2 with large opening of the lens and 14 inches striking distance; Fig. 3, short exposure, sawtooth wave current from ironclad alternator.

The following phenomena appear to take place: An electrostatic discharge of oscillating nature strikes across the electrodes. This discharge starts an alternating arc between the electrodes, which first follows the path of the discharge, then flares upward, in its center first, due to the upward rise of the intensely heated air, while its sides eddy round in an erratic manner and then flare upward also. This arc never breaks spontaneously, but frequently jumps across space by bifurcation, and rises to a height considerably in excess of the distance of the electrodes. It finally assumes the shape of two flames issuing from the electrodes and curving sharply upward, joined at the top by bridges of flame in rapid and erratic motion. At the same time the two sides tend to separate from each other and to run back along the electrodes.

The oscillating discharge is of intense brilliancy, and therefore shows, on all the photographs where a larger opening of the lens was used, as a dark line, due to the reversal of the photographic plate by over-exposure (solarization).

It can best be studied on Figs. 1 and 3, where a small opening of lens was used.

It is very sharply defined, has the usual zigzag course of an electrostatic discharge, but consists of a number of distinct oscillations which follow only approximately, but not completely, the same path. They look like threads twisted loosely together. Two oscillations can be distinguished throughout, one, apparently the first discharge, of greater width and brilliancy than the other or return stroke. On most photographs on many places a third oscillation can be distinguished as a line interwoven with the first two, but still fainter. In a few instances it begins to get blurred.

The existence of these successive oscillations and the distinct courses followed by them are very remarkable, and were quite unexpected. Since the self-induction and capacity of the system are comparatively small, and the available power far in excess of that necessary to maintain an arc, I expected that the first discharge would short-circuit the spark gap and start an arc. The existence of successive oscillations following distinct courses seems to prove that the dielectric or disruptive strength of air is not completely broken down by a single discharge, as is generally assumed, and not even greatly weakened, since the second and third oscillations follow only approximately the same path. Thus a number of successive discharges or oscillations seem necessary to gradually weaken the dielectric strength of air so as to allow an arc to start.

Second—The arc established by the oscillating spark first follows its path, but gradually leaves it. Each half wave of the alternating current is marked by a striation on the photograph. These striations follow each other in parallel curves. The gradual drift of the arc from the path of the original spark is best seen in Fig. 2.

Apparently the air, intensely heated by the arc, begins to rise up in some place, generally the center, and thereby forces the air downward in some other place and thus forms a strong eddy.

The upward flare and the eddy are shown in Fig. 1. This seems to express the mechanism. The heated air rises upward and carries the center of the arc up into a flare, but the upward current of air forces air downward on either side and thereby bends the sides of the arc down into cones or hollows, as seen in the engraving.

Fig. 2 shows the upward flare of the arc completely

FIG. 1.—SHOWING UPWARD FLARE AND EDDIES.

FIG. 2.—LARGE APERTURE. 14-INCH STRIKING DISTANCE. SHOWING STRIATIONS AND DARK CENTRAL SPACE.

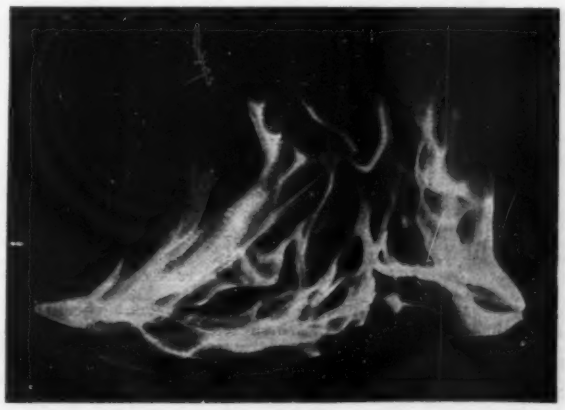


FIG. 3.—SHORT EXPOSURE. SAW-TOOTH WAVE CURRENT FROM IRONCLAD ALTERNATOR.

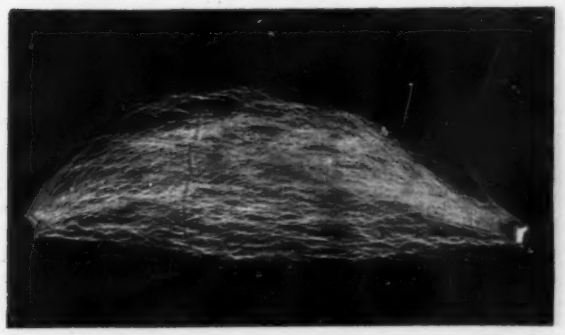


FIG. 4.—THREE SECONDS EXPOSURE. SHOWING MORE OSCILLATIONS.

*Electrical World.

developed, with a black space in the very center where the arc has jumped across by joining again above and then breaking below.

This photograph also shows the running backward of the arc along both electrodes, due to the dynamic repulsion of the currents in the two sides of the arc which flow in opposite directions. This repulsion is shown also by the sharp upward bend of the side flames in the following photograph.

Fig. 5 shows the striations most markedly. Since the time between adjacent striations is that of a half period of 1-250 second, the rapidity of the upward motion of the air can be estimated from the distance of adjacent striations. Where they are furthest apart the air velocity must be about 10 feet per second.

The sparks in photograph Fig. 5 is blurred, due to the large lens aperture used, and reversed or solarized. The exposure in this case was about two seconds.

The top space of these photographs is completely filled with striations of approximately horizontal direction and considerable distance from each other, showing that the arc bridging across the space between the two stationary terminal flames was in rapid eddying motion upward and downward.

Fig. 3 shows the disruptive discharge caused by an iron-clad alternator of the ordinary saw tooth wave form. It does not differ much from the previous photographs in its nature, except that the discharge is somewhat fainter, due to the lesser power available in the discharge circuit in consequence of the high synchronous impedance of the iron-clad alternator (a 60-kw. machine).

The conclusions drawn from these photographs are:

First.—The discharge of a high potential circuit is always oscillating, even if sufficient power is behind the circuit to maintain an arc; and a number of successive oscillations are necessary to weaken the disruptive strength of air sufficiently to maintain an arc. Thus the dielectric strength of air is not reduced to zero by a single electrostatic discharge or rupture, but on the contrary is still sufficiently high to force the next oscillation into a somewhat different path.

Second.—An arc impelled by extremely high voltage and with considerable power behind is in continuous and very rapid eddying motion, flaring upward due to the upward draught of heated air. It never extinguishes itself, but frequently appears to jump across space by what seems to be bifurcation.

For comparison there is shown in Fig. 4 a (powerless) oscillating discharge of very high frequency, about 150,000 cycles per second.

The terminals are the same as in the previous photographs, the striking distance is 9 inches (corresponding at low frequency to about 90,000 volts).

As may be seen in this discharge, no arc follows the spark, but every set of oscillations gives a separate and distinct spark, although with long exposure a noticeable upward flare of the successive sparks is shown. The sparks show the same character as the starting spark of the power discharge in the previous photographs, that is, an erratic, zigzag course. The individual oscillations of each discharge cannot be distinguished in the photograph, but each spark corresponds to a complete set of oscillations as produced by one condenser discharge, that is, one-half wave of the alternating supply current.

These sparks are produced by a oscillating condenser discharge. By an open magnetic circuit transformer having a ratio of turns of 1 to 300 the 125 cycle alternating supply current is stepped up in voltage and charges a mica condenser of such a capacity as to give nearly complete resonance, as shown by the rise of the ratio of transformation to about 1 to 700. This condenser discharges at about 20,000 volts over a series of seven small spark gaps through the primary of a Thomson transformer, whose secondary connects to the terminals of the disruptive discharge. The Thomson transformer consists of an external primary of a small number of turns and an internal secondary of a larger number of turns, both submerged in oil, but without iron core.

From the inductance and capacity of the discharge circuit an approximate frequency of oscillation of 150,000 cycles per second is calculated. The total input in the step-up transformer is about 1 kilowatt, of which only a small part appears in the distributive discharge.

This discharge seems to be harmless. To try the physiological effect of the powerful discharges would not be advisable.

DE KERMODE'S RUDDER MECHANISM.

THE rudder of a ship is an apparatus of great importance, to the study of which considerable attention has been paid. Upon the one hand, the reduction of the stresses to be employed for the maneuvering of this apparatus and, upon the other, the suppression of the reactions so dangerous to the pilot, where the steering is done by hand, and so injurious to the mechanism in transmissions of power, constitute two of the essential points of the installation of rudders.

The ingenious motive apparatus by means of which it is possible, in developing but a slight stress, to maneuver the rudder of the largest steamer with rapidity and precision are well known.

As for the second desideratum, the question of the solution of that by independent means has recently been solved in a manner which is so much the happier in that it deals entirely with the intermediate parts employed between the transmission of power and the rudder stem.

This invention, which is due to Mr. De Kermode, has been successfully applied to several large warships and merchantmen. Figs. 1 and 2 show the various parts of a rudder mechanism of this system.

The apparatus consists of a large disk, A, movable around the stem, P, and carrying upon its upper surface two eccentric semicircular guides, each formed of angled steel, bolted to the disk. Upon the stem, P, is keyed a crosshead which is jointed at diametrically opposite points with the connecting rods, N R, of which the other extremities are connected with the frames, F, arranged in the direction of the ship's breadth.

These frames are held rigidly in this direction by two rods, G G, which traverse them and pass into a sleeve moving freely at the end of the stem, while at their extremities they are fixed by supports to the stern-post.

Each of these frames carries beneath and at its center a strong bolt that traverses a slide which is adjusted in the eccentric guide that corresponds thereto. At each end of the support of this bolt is placed, upon each of the transverse rods, G, a spiral spring designed to absorb the shocks that the rudder receives from the waves. Under such circumstances, the waves simply produce upon the angle steel of the guide, G, a pressure directed almost at a right angle, and so nearly thereto that there results no tendency toward a rotation of the disk, A.

Whatever be the state of the sea, the rudder, consequently, remains in the position to which it has been brought, or at least returns to it automatically under the action of the springs after yielding to the shock of a wave; so that there is no need of putting more men at the wheel when the steering is done by hand in bad weather, and no fear that the steersmen will be knocked down and injured.

As the effect of an impact of the waves is not transmitted to the maneuvering apparatus, it is possible to employ, indifferently, toothed wheels, chains or cables for transmitting motion from a motor or from a rudder wheel to the disk, which is substituted for a tiller.

When a rotary motion is communicated to this disk, the guides, C E, revolve eccentrically around the rudder stem and force the slide to displace itself along the guide bars, C G, that is to say, to approach or recede from the stem radially. The frames, F, participate in such motion, and, through the connecting rods, N R, oblige the crosshead to take the desired direction.

In the example represented, a conical pinion of gun metal connected with the transmission of the motor gears with a face wheel fixed beneath the disk. This face wheel is divided into segments that it is possible to make pass from an active to an inactive position when a tooth of one of the segments chances to get broken.

It will be seen from an inspection of the figures that the crosshead is provided, beyond the joints of the connecting rods, with apertures, each of which corresponds to an aperture formed in the disk. In case of accident to the machinery, it is possible to couple the crosshead directly with the disk by means of strong eye bolts placed in the vicinity. It is necessary, beforehand, to release the slides of the guides, C E, by removing their axes.

The adaptation of this mechanism to ships of different types is exceedingly easy.

When the transmission is effected through cables, the inconveniences that result from their stretching are here avoided; if it is a question of chains, the disappearance of the incessant noise which they usually make is particularly agreeable to passengers; finally, in the use of gearings, the teeth are protected against the continual shocks that result from the waves and that cause so great damage to these parts that there often results a rapid destruction thereof.

Moreover, the metal is used very judiciously. The disk is of cast steel, and the eccentric guides and spring frames are of forged steel, while the slides are of gun metal.

One important advantage of this mechanism consists in the fact that the utilization of the power of the engine (or, in the case of a maneuver by hand, of that of the stress transmitted by the pilot) increases proportionally in measure as the rudder turns more to port or starboard, and the resistance exerted by the water, consequently, increases. In other words, the greater the angle made by the disk, the higher the ratio of the levers that intervene in the maneuver of the rudder stem.

Upon the upper deck of the vessel there is usually a double wheel for the control of the rudder by means of an intermediate transmission, while amidships and at the stern there is a simple maneuvering wheel that permits of actuating from these two points the transmission shaft that controls the distribution of steam of the motor.—Revue Industrielle.

Fig. 1.

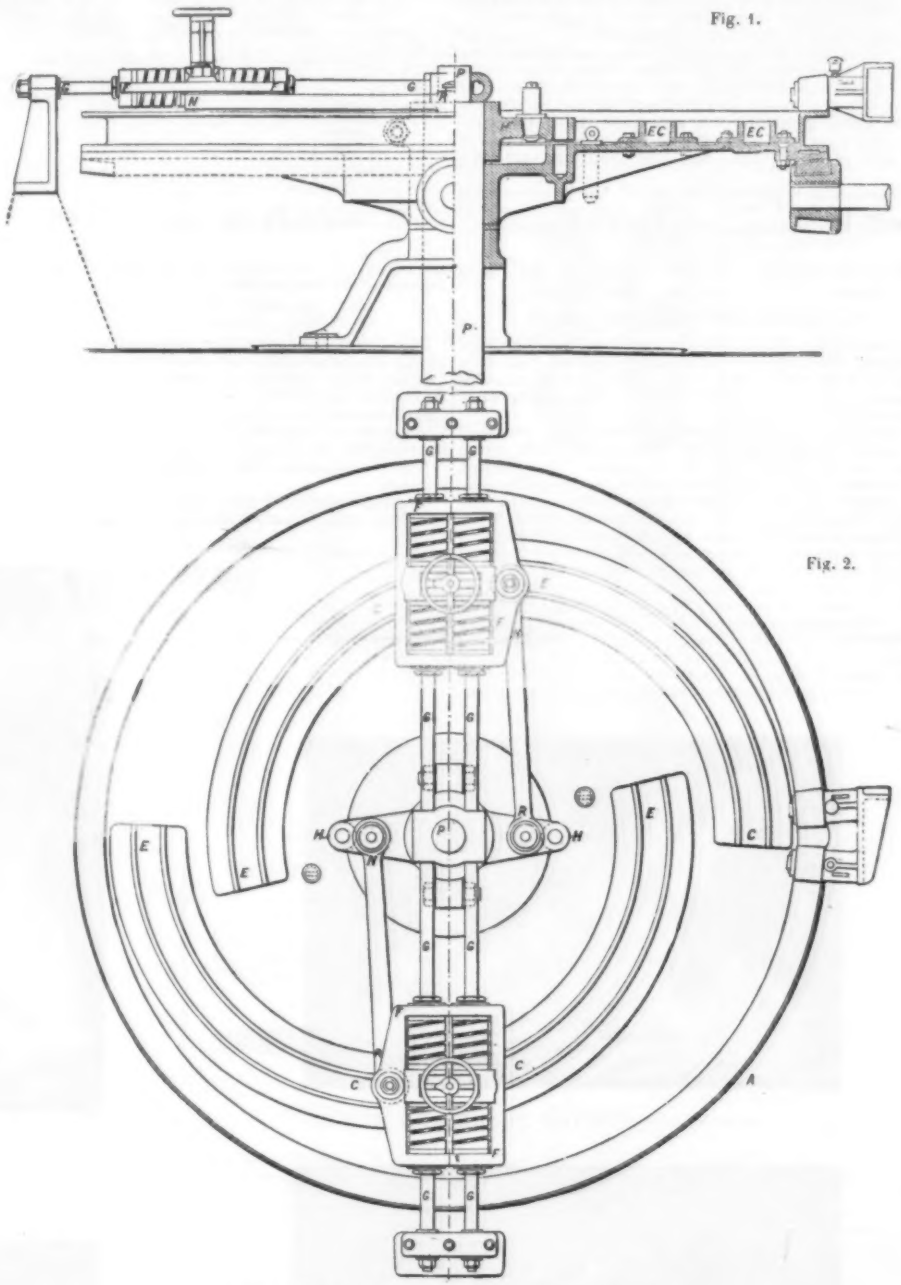


Fig. 2.

DE KERMODE'S RUDDER MECHANISM.

The following particulars regarding the book trade in Spain have been received from Consul General Bowen, dated Barcelona, April 5, 1897: During the last five years, 16,463 books have been copyrighted in Spain, of which 10,000 are credited to Madrid and the rest to the other cities of Spain. The average number of books published in Spain yearly is 1,176, of which 790 are printed in Madrid, 239 in Barcelona, and the rest principally in Seville, Valencia and Saragossa. The explanation of the paucity of literary productions in Spain is to be found, Señor Diaz Pérez asserted recently, in the fact that of the 17,500,000 inhabitants of Spain, only 6,000,000 can read and write. That there should be a large demand for the works of Spanish authors might be inferred from the fact that there are 65,000,000 Spanish-speaking people in the world; but recent statistics prove that only 3 per cent. of the Spanish books imported by the 38,000,000 Spanish-speaking inhabitants in the western hemisphere come from Spain, while the remaining 97 per cent. are imported from countries whose language is not Spanish.

THE SOLUTION OF THE FLIGHT PROBLEM.

THE study of aerial navigation is awakening more general interest, and the public no longer regards the flying machine as a castle in the air, even though successful inventors still complain of the lack of financial support. This lack of financial assistance may be accounted for by the general prevalence of the opinion that capital invested in the solution of the problem of flight is as good as thrown away; and the wealthy merchant, calculating in his practical way, argues: "What advantage is there for me in procuring my goods by means of airships, if I can obtain them more cheaply by land or water?" The scientist, in return, says that the solution of the problem of artificial flight possesses a great scientific value as regards the discovery of the pole and other unexplored regions. The merchant retorts: "Of what use is that to me? I wish to procure my goods more cheaply; otherwise, as far as I am concerned, the solution of this problem will be of no value."

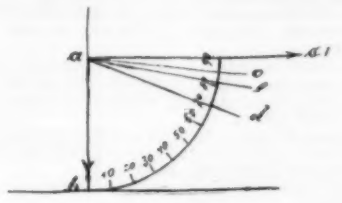


FIG. 1.

The question now arises: Is it really possible to transport burdens through the air cheaper than by land or water? This question may be answered with a most decided "Yes." The problem will, however, be solved, not by means of gas-balloons, the propulsion of which by machines must first be laboriously studied, but by flying apparatus built on the principles of bird flight. Only by the latter means is it possible to make the burdens themselves perform the greater part of the work necessary for their transportation—a method which I have advocated for several years.

FIG. 2.

Captain Halla, of Graz, informed me in a letter dated October 25, 1897, that after he had read one of my articles on aerial forces, in which I stated that the force of gravitation was the principal force to be considered in flying, he for the first time met with a theory of artificial flight which agreed with his own. "For," said he, "I shot a flying eagle through the breast in such a manner that the ball emerged again through the spinal column; the bird immediately shot down and suddenly, while still at a distance of some seventy-five feet from the earth, spread out its wings, and lying horizontally, glided without the slightest motion of its wings for a distance of about 500 paces to a meadow, where I found it dead, wings outspread, just as it had glided. The bird was therefore dead even before it reached the earth."

FIG. 3.

This is all to be regarded as strictly true; for, just as birds which have been fired upon wing away with their utmost bodily strength in order to escape from their pursuers, and just as every animal whose spinal cord has been injured immediately becomes paralyzed and is said to extend its limbs, so it is probable that this bird, wounded in the same manner, expanded its wings in the stiffness of death and traveled a distance equal to twenty times the height from which it fell. According to an account given by an engineer named Gelinek (Komotau), it seems that partridges also, after good shots, fall gradually to the earth.

What, then, can this phenomenon of the dead gliding eagle advance toward the explanation of the art of flying?

Every body that follows the direction of its force of gravity will fall perpendicularly to the earth. But the more it swerves from its line of fall, the greater must be the lateral pressure which forces it from this line. If a body is driven laterally so that it glides along horizontally, then its whole force of gravity is neutralized or absorbed in lateral force.

I have seen a leaf from a tree sailing sideways, which floated to a distance equal to thrice the height of its starting point, and yet no breeze was stirring; the leaf being therefore impelled only by natural forces. Lilienthal glided without a motor from the Rhinow Hills, 98 feet in height, to a distance of 820 feet, i. e., to a distance equal to eight times the height.

In Fig. 1, *a b* is the perpendicular line of fall, which makes an angle of 90° with the horizontal. The gliding line of the leaf is *d*, which makes an angle of 70° with the perpendicular; the line, *e*, is the course taken by Lilienthal, and represents a lateral force of about 81°; the line, *o*, indicating 85°, is the angle made with the perpendicular by the gliding line of Halla's bird. If to the weight of the dead bird a lateral force represented by 5° had been added, the resulting angle would have been 90°, i. e., horizontal flight would have been attained; in other words, the entire force of gravity of the dead bird would have been rendered inactive.

The dead gliding bird thus proves that with proper wings it is possible, by mere gravitation alone, to perform $\frac{85}{90}$ of the work necessary for horizontal flight, requiring therefore only a small auxiliary force equal to $\frac{5}{90}$ of the gravitation of the mass to reach the desired end. The solution of the problem of flying consequently demands no very great force, as my opponents have continually estimated, but, on the contrary, only a very small force, since the mass is carried along largely by its own weight.

Since, in the transportation of bodies, work must be performed which is equal to the force exerted times the distance traversed, and since birds in flying must also perform this work, the question arises: Where did the force for transporting the dead bird to a distance of 500 paces come from? The force came from the vertical air pressure upon which the wings of the falling bird acted. This pressure, similar to that of a parachute, may be considered as sail pressure upon the formation of an angle of small inclination by the tips of birds' wings. Every plane surface which sinks through the air while lying horizontally, will fall perpendicularly like a parachute; but, should it be inclined ever so little, it will then fall in the direction of its inclination. The tips of a bird's wings, having the tendency to fall forward, will therefore cause the bird to follow the direction of their inclination, the body of the bird meanwhile slowly sinking.

How strong, then, is this sail pressure with its power of impulsion? It is a pressure which under certain conditions can be so great as to be equal to the gravitation of the gliding mass. For, since the wings carry the weight of the bird, and the wings in their turn rest on the air, the pressure of the wing-surface on the mass of air cannot be less than the force of gravity of the bird. This in the stork, for example, amounts to about nine pounds. The portion of the pressure which acts on the tips of the wings is impelling sail pressure. If the stork inclines its wings only to a slight extent, an impelling pressure of approximately nine pounds will be produced.

The gliding of the dead body is consequently accounted for by the fact that the bird, which was lying horizontally, was carried on only by the pressure on the tips of its wings; and during this onward propulsion it slowly sank to the earth.

The lateral air pressure which we call wind drives ships through the sea, but only when it is present; for often the wind slumbers; now it is strong, now feeble; now it comes from here, now from there; now it blows steadily, now in gusts—in brief, the wind is an incalculable factor which often disappoints us when we need it most. But is it otherwise with the vertical air pressure under the wings of a bird? As soon as a bird casts

FIG. 4.

itself into the air and rests on its wings, it is incessantly impelled onward by the vertical aerial pressure under its wings. This onward impulsion, it is true, can be made faster or slower by the wind in relation to the earth's surface, but no gale can render the vertical air pressure under the wings powerless; for this pressure always remains constant, though there be wind or not, though the bird turn whither it will. At all times and in all places will the creature be spontaneously driven on by this constant force in an approximately horizontal direction, so that only a small auxiliary force is necessary for absolutely horizontal flight.

Here we have those powerful, constant, incessantly acting natural forces which in the future will carry burdens from country to country, over land and sea, forces which, moreover, will never disappoint us. Before us there now appears an encouraging prospect for the intercourse of the nations of the future, since we need not produce by artificial mechanical forces the work which natural forces perform for us.

But the bird must, however, produce by its own muscular exertions the force necessary for sustaining the weight of the body between its wings. This is the important force which we can entirely dispense with in the solution of the problem of flying; for even as it was produced in the bird by rigidly holding its wings in the stiffness of death, so we can keep our wings rigidly expanded by rods and braces, requiring, therefore, no mechanical force but only material force for the transportation of our burdens through the air.

If consequently the rods sustain the burden and the wings perform the greater portion of the work necessary for urging on the load, is the solution of the problem under these conditions so very remarkable? To what devices have we not already resorted in order to solve the problem of flying! Maxim required 350 horse power in his machine for propelling a load of 8,800 pounds through the air; Wellner reckoned that 100 horse power would be necessary for the transportation of sixteen persons; Von Parsevall, Stenzal and Langley require similar power. Langley's model traversed a distance of about 5,250 feet in 1¼ minutes; the model weighed only 28¾ pounds, but a full horse power was required to drive it through the air. What a waste of power!

A rational method of transportation does not demand the use of the greatest possible power, but the least possible; and for this reason only, that theory of flying can be of any value which provides the greatest amount of work for the least expense of energy.

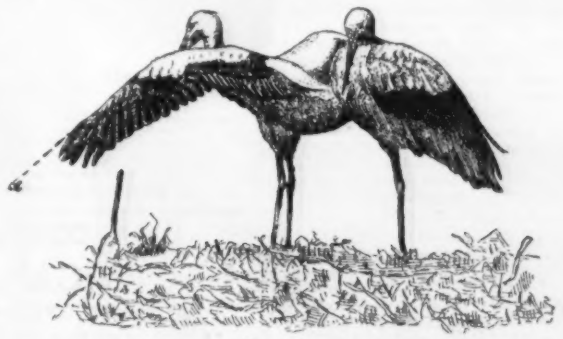


FIG. 5.

The most efficient services are, however, performed by the wings of birds; for, by their inherent elasticity, they are enabled to yield before the pressure of the air, and, as soon as the resistance permits, to spring back to their initial position. Nature has, therefore, concentrated in the elastic expansion of the wings of birds all effective flying forces; i. e., when the wings sustain merely the weight of the bird, they have the expansion necessary to counteract the force of gravity. This is illustrated in Fig. 2, where the first of the remiges or

primaries is extended in front of the line, *a* (the continuation of the bones of the forearm). In Figs. 4 and 5, however, the tips of the feathers lie behind the line, *a*, since the wings are not supporting the weight of the bird.

In the wing indicated in Fig. 3, only the mere force necessary to counteract the gravitation of the mass is accumulated, caused by the fact that the wings are not in motion. It was with this force of expansion that Halla's dead bird glided. The motion in this latter instance was therefore no longer one of sailing, but a continuous motion of expansion, due to the force exerted by the forward extension of the horizontal remiges. In this forward expansion, a horizontal component is contained, because the vertical air pressure continually pushes the feathers toward the front and then glances from the wings, since their structure so demands it.

In Fig. 3 of the accompanying illustrations (drawn from instantaneous photographs, taken by Anschütz), the stork is completing a single stroke of its wings; in order to fly, the bird is also employing active muscular force, and this additional power must make its appearance in some particular place. This place is found in the tips of the remiges, and we therefore see them extended in front of the line, *a*, even more than in Fig. 2, because the force of expansion in the wing is now gravitation plus the expansion due to active muscular force. From this it is readily perceived that the flapping of the wings is not the principal impulsive force in flying, but only an important auxiliary power—a mere strengthening of the energy already existing. For this reason the bird, when flapping his wings, flies more swiftly than when they are at rest.

As soon as the account of this shot of Halla's reached the ears of Dr. Gerstmann, the publisher of "Urania," a journal given up to correspondence on natural science, he wrote to me saying he was interested in this case; but if it were to appear credible, I would have to produce the original letter of the marksman, and, secondly, what was of more importance, I would have to prove the existence of those horizontal components which, according to my theory, had carried the dead bird to so great a distance. Upon this I produced Halla's letter, together with a printed essay illustrated by instantaneous photographs of flying storks, in which this horizontal component of expansion was particularly treated. Dr. Gerstmann now recognized the correctness of my theory and wrote in his "Urania" that the energy of expansion accumulated in the wings could be transformed into work, like all energy, without the production of any special power on the part of the bird.

This shot of Halla's is particularly interesting to me, because I never believed that a bird of that species could be shot and remain gliding in the air, with wings outspread. It was only to assist my readers in comprehending my theory that I wrote the following lines on page 67 of my work, "Das Flugprincip" (The Principle of Flying), a private publication:

"This force (the force of expansion in the wings) is similar to an accumulator which faithfully gives off the power which it has collected, and yet remains fully charged. The wings are similar to magnetic organs, constantly attracted to a pole which they never reach; which always lies before them, turn whither they will,—in a word, the bird moves through the air without flapping its wings, adding nothing directly to its motion except the spreading out of its wings. Under these conditions, is the art of flying anything wonderful? We need only sustain ourselves in the air by proper steering apparatus, and then we have at the same time obtained a continuous forward impulsion.

"It is an actual fact that, were it possible to shoot a bird circling in the air, so that it would remain in equilibrium—dead and stiff—it would continue to glide in circles until it reached the earth. Since the bird, while gliding thus, retains an almost constant height, considerable time might be required before it would finally reach the ground. A slight auxiliary force would amply suffice to continue its flight."

I wrote that five years ago. Theory and practice have agreed with each other in a most gratifying way, and I now ask, was my theory deduced from Halla's shot, or did the actual occurrence bear out my statement?

To those who understand ever so little of this problem of artificial flight, there speaks a voice which says: Why do you seek these powerful forces and machines? Is not the greatest power to be found in the force of expansion produced by transformed gravitation? And, while you are compelled to use powerful machinery for the transportation of burdens over land and sea, your goods may be spontaneously carried through the air by an approximately horizontal gliding motion, which may be continued as long as you wish, by a slight additional force. For, if this auxiliary force be removed, with whose assistance a horizontal gliding motion was attained, then the latter ceases and only an approximately horizontal motion remains, which is, however, always present. A force is, therefore, constantly at your disposal, even though your burden is sustained in the air for weeks. You have here a powerful, incessantly acting natural force,—a force which will never disappoint you, upon which you may count with mathematical precision.

I leave to the imagination of all thinking men the possibilities of aerial navigation in the commerce of the future. I am only curious to know when I shall be understood and supported in my native land.

KARL BUTTENSTEDT, in Stein der Weisen.

A Dresden chemist, M. Deninger, suggests a new process for the protection of iron structures against the injurious action of rust. The process, says The Progressive Age, consists in treating the iron with a solution of ferrocyanide, which gives place to the formation of a coating of cyanide of iron, uniform and impermeable to water, of such a nature as to protect effectively the iron covered. This operation, applied on a large scale, has already given good results. The following is the method adopted in practice. The solution is mixed with a flaxseed varnish to which has been added a little turpentine or benzol, so as to cause a very homogeneous emulsion which can be applied without difficulty. The evaporation of the alcohol leaves the flaxseed varnish, which forms a coat protecting the cyanide of iron which is deposited upon the iron. There is no necessity of previously preparing the iron in any way beyond removing the beds of rust which are too thick to admit of the action of the ferrocyanide.

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